**U.S. DEPARTMENT OF COMMERCE**
**National Technical Information Service**

PB-263 557

# Chloride and Nitrogen Concentrations Along the West Shore of Lake Erie

**Michigan State Univ, East Lansing Inst of Water Research**

**Prepared for**

**Detroit Edison Co, Mich**

May 76

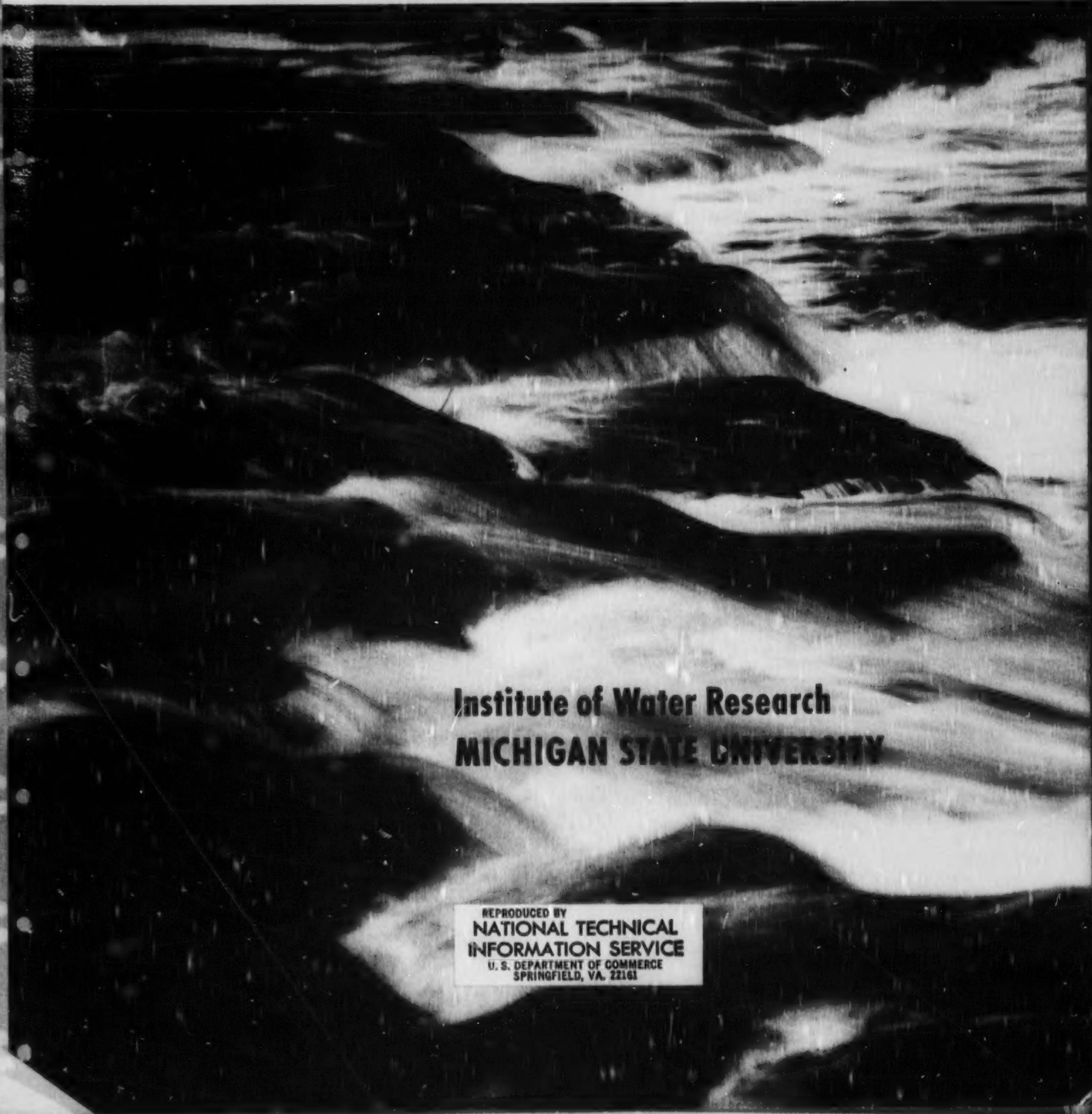
PB 263 557

Technical
Report
No. 32.8

May 1976

# CHLORIDE AND NITROGEN CONCENTRATIONS ALONG THE WEST SHORE OF LAKE ERIE

by T.J. Ecker and R.A. Cole



**Institute of Water Research**
**MICHIGAN STATE UNIVERSITY**

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

| | | | |
|---|---|---|---|
| **BIBLIOGRAPHIC DATA SHEET** | 1. Report No.<br>MSU-IWR-TR- 76-0032.8 | 2. | 3. Recipient's Accession No. |

4. Title and Subtitle
CHLORIDE AND NITROGEN CONCENTRATIONS ALONG THE WESTERN SHORE OF LAKE ERIE

5. Report Date
May, 1976

6.

7. Author(s)
Thomas J. Ecker and Richard A. Cole

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Department of Fisheries and Wildlife and
Institute of Water Research
Michigan State University
East Lansing, Michigan 48824

10. Project/Task/Work Unit No.

11. Contract/Grant No.
X-290059

12. Sponsoring Organization Name and Address
The Detroit Edison Company
2000 Second Avenue
Detroit, Michigan

13. Type of Report & Period Covered
Interim 5/70-6/75

14.

15. Supplementary Notes
Thermal Discharge Series

16. Abstracts

Chemical concentrations of chloride and selected nitrogen parameters were measured in the area near the western shore of Lake Erie over the period of May, 1970 to June, 1975. Samples were taken at six stations in Lake Erie in the vicinity of the Detroit Edison Monroe Power Plant as well as in the Raisin River and the power plant discharge canal. The study began one year before the power plant began operating and continued until full operation was reached.

Chloride was used as a conservative element to determine the relative contributions of the three major tributaries in the study area, the Detroit, Maumee, and Raisin Rivers. Changes in nitrogen parameter concentrations were noted with respect to chloride concentrations.

17. Key Words and Document Analysis. 17a. Descriptors

Thermal discharge
Fissil-fuel plant
Chloride concentrations
Nitrogen concentrations

17b. Identifiers/Open-Ended Terms

Monroe, Michigan
Lake Erie
Maumee River
Raisin River
Detroit River
Once-through cooling

17c. COSATI Field/Group

18. Availability Statement Release unlimited.
Available from National Technical Information Service, Springfield, VA 22151

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 144

22. Price 6.00 - 3.00

THIS FORM MAY BE REPRODUCED

# CHLORIDE AND NITROGEN CONCENTRATIONS ALONG THE WEST SHORE OF LAKE ERIE

by

Thomas J. Ecker
and
Richard A. Cole

Department of Fisheries and Wildlife
Institute of Water Research

Michigan State University
East Lansing, Michigan 48824

Technical Report No. 32.8
Thermal Discharge Series

Institute of Water Research

May 1976

This study was supported with funds from the Detroit Edison Company and the U.S. Environmental Protection Agency.

# ABSTRACT

## CHLORIDE AND NITROGEN CONCENTRATIONS ALONG THE WEST SHORE OF LAKE ERIE

Chemical concentrations of chloride and selected nitrogen parameters were measured in the area near the western shore of Lake Erie over the period May, 1970, to June, 1975. Samples were taken at six stations in Lake Erie in the vicinity of the Detroit Edison Monroe Power Plant as well as in the Raisin River and the power plant discharge canal. The study began one year before the power plant began operating and continued until full operation was reached. Similar chemical data was obtained from a three year U. S. Environmental Protection Agency sponsored study of the power plant cooling system. Additional chemical data were obtained from various agencies for the Detroit and Maumee Rivers.

Chloride was used as a conservative element to determine the relative contributions of the three major tributaries in the study area, the Detroit, Maumee, and Raisin Rivers. Changes in nitrogen parameter concentrations were noted with respect to chloride concentrations.

Water in the near shore lake stations consisted primarily of Detroit River water. The composition ranged from 74 to 95% Detroit River water, the highest value occurring in the fall and the lowest in the spring. The Maumee River had its greatest impact in the spring, making up 14 to 18% of the lake water. Its contributions

dropped to about 11% in the summer and 5% in fall. Apparently Maumee River water mixes with Detroit River water and retains these proportions as the water moves northward through the study area. The impact of the Raisin River was shown to be greatest at the lake station closest to the river output, and ranged from 12% in the spring down to 5% in the fall.

Nitrate concentrations in the lake were determined by tributary inputs and showed a distinct maximum in spring. Nitrate decreased through the year from assimilation and dilution. Organic nitrogen increased slightly through the growing season, but ammonia nitrogen showed much less seasonal variation than either nitrate or organic nitrogen. The most important source of nitrogen in the study area is the nitrate received from the Maumee and Raisin River watersheds during heavy winter and spring runoff. Concentrations of inorganic nitrogen measured in the lake did not agree well with calculated values. There seemed to be a deficit of from 25 to 50% in spring and fall and 65 to 75% in summer by the time the water entered the study area from the south. There was no compensating change in organic nitrogen. In addition, there was a continued loss of nitrate as the water moved through the study area although ammonia increased in partial compensation. Insufficient data exists to determine whether the nitrogen is lost to the atmosphere or sediments. Due to the relatively high inorganic nitrogen present through all seasons, nitrogen fixation would seem to be insignificant in the study area.

The power plant cooling system has little if any effect on the nitrogen concentrations beyond those due to mixing of Raisin River water with Lake Erie water prior to its discharge into the lake. There may be a slight loss of ammonia nitrogen in spring, but little if any change in organic, nitrate, or total nitrogen. Effects of the Raisin River-discharge canal system are undiscernable more than 5 km distant as the water rapidly mixes to ambient temperature and chemical concentrations. Chloride concentrations in the lake were shown to be closely related to nitrate nitrogen concentration, but not to ammonia or organic nitrogen.

## TABLE OF CONTENTS

Page

INTRODUCTION . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1

DESCRIPTION OF THE STUDY AREA . . . . . . . . . . . . . . . . . . . 3

Western Basin of Lake Erie . . . . . . . . . . . . . . . . . . 3
General Description . . . . . . . . . . . . . . . . . . 3
Hydrodynamics . . . . . . . . . . . . . . . . . . . . . . 5
Water Quality . . . . . . . . . . . . . . . . . . . . . . 11
The Monroe Power Plant . . . . . . . . . . . . . . . . . . . . 12
Sampling Locations . . . . . . . . . . . . . . . . . . . . . . 15
The Detroit Edison Sites . . . . . . . . . . . . . . . . . 15
The U.S.E.P.A. Sites . . . . . . . . . . . . . . . . . . 16
Other Data Sources . . . . . . . . . . . . . . . . . . . 18

METHODS AND MATERIALS . . . . . . . . . . . . . . . . . . . . . . . 21

RESULTS AND DISCUSSION . . . . . . . . . . . . . . . . . . . . . . 24

Chloride and Hydrodynamics . . . . . . . . . . . . . . . . . . 24
Nitrogen . . . . . . . . . . . . . . . . . . . . . . . . . . . 38

CONCLUSIONS . . . . . . . . . . . . . . . . . . . . . . . . . . . . 59

LITERATURE CITED . . . . . . . . . . . . . . . . . . . . . . . . . 62

APPENDICES . . . . . . . . . . . . . . . . . . . . . . . . . . . . 66

**Preceding page blank**

# LIST OF TABLES

Table Page

1 Mean, maximum, and minimum discharges of the Detroit, Maumee, and Raisin Rivers . . . . . . . . . . . . . . . . . . . . 10

2 Seasonal and annual mean chloride concentrations at selected sites in Lake Erie and its tributaries . . . . . . . . . 25

3 Annual mean chloride concentrations in the discharge canal and plume . . . . . . . . . . . . . . . . . . . . . . . . . 32

4 Mean relative composition of lake stations based on chloride concentrations . . . . . . . . . . . . . . . . . . . . 37

5 Seasonal concentrations of nitrogen species in the Raisin River . . . . . . . . . . . . . . . . . . . . . . . . . . 44

6 Calculated and measured nitrogen parameters at lake stations 5 and 4 assuming that northward moving lake water mixes with Raisin River water . . . . . . . . . . . . . . 45

7 Annual nitrate nitrogen concentrations in the discharge canal . . . . . . . . . . . . . . . . . . . . . . . . . . . . 48

8 Annual ammonia nitrogen concentrations in the discharge canal . . . . . . . . . . . . . . . . . . . . . . . . . . . . 49

9 Annual organic nitrogen concentrations in the discharge canal . . . . . . . . . . . . . . . . . . . . . . . . . . . . 50

10 Annual total nitrogen concentrations in the discharge canal . . . . . . . . . . . . . . . . . . . . . . . . . . . . 51

11 Seasonal nitrate and ammonia nitrogen concentrations in the Maumee and Detroit Rivers . . . . . . . . . . . . . . . . . 54

Table Page

12 Inorganic nitrogen concentrations as measured in the lake and as predicted from chloride concentrations . . . . . . . . . . 55

13 Nitrate nitrogen concentrations as measured in the lake and as predicted from chloride concentrations . . . . . . . . . . 56

14 Ammonia nitrogen concentrations as measured in the lake and as predicted from chloride concentrations . . . . . . . . . . 57

APPENDICES

A1 Mean concentration of chloride in mg/l station . . . . . . . . . 66

A2 Mean concentration of total nitrogen in mg/l by station . . . . 72

A3 Mean concentration of nitrate nitrogen in mg/l by station . . . 80

A4 Mean concentration of Kjeldahl nitrogen in mg/l by station . . 88

A5 Mean concentration of ammonia nitrogen in mg/l by station . . . 96

A6 Mean concentration of organic nitrogen in mg/l by station . . . 104

A7 Mean concentration of inorganic nitrogen in mg/l by station . . 112

A8 Seasonal and annual means of chloride concentration in mg/l by stations . . . . . . . . . . . . . . . . . . . . . . . . 119

A9 Seasonal and annual means of total nitrogen concentration in mg/l by stations . . . . . . . . . . . . . . . . . . . . . . . 121

A10 Seasonal and annual means of nitrate nitrogen concentrations in mg/l by stations . . . . . . . . . . . . . . . . . . . . . . . 123

A11 Seasonal and annual means of total Kjeldahl nitrogen concentrations in mg/l by stations . . . . . . . . . . . . . . . 125

A12 Seasonal and annual means of ammonia nitrogen concentrations in mg/l by stations . . . . . . . . . . . . . . . . . . . . . . . 127

A13 Seasonal and annual means of organic nitrogen concentrations in mg/l by stations . . . . . . . . . . . . . . . . . . . . . . . 129

A14 Seasonal and annual means of inorganic nitrogen concentrations in mg/l by stations . . . . . . . . . . . . . . . . . . . . . . . 131

# LIST OF FIGURES

| Figure | | Page |
|---|---|---|
| 1 | Map showing the location of sampling sites in the western basin where chloride and nitrogen concentrations were measured . . . . . . . . . . . . . . . . . . . . . . . . . | 4 |
| 2 | Resultant wind direction in tens of degrees and wind speed in km/hr during the study period . . . . . . . . . . | 6 |
| 3 | Monthly Detroit River discharge and weekly discharge of the Maumee River . . . . . . . . . . . . . . . . . . . . . . | 7 |
| 4 | Weekly Raisin River discharge and monthly precipitation at Monroe, Michigan . . . . . . . . . . . . . . . . . . . | 8 |
| 5 | Map showing the vicinity of the Monroe Power Plant and sampling locations in the cooling system. Locations of Stations 15 and 16 are from samples obtained in the thermal plume which altered position with wind changes . . | 13 |
| 6 | Map showing the location of the 1975 random sampling sites . . . . . . . . . . . . . . . . . . . . . . . . . . | 17 |
| 7 | Chloride concentrations at lake Stations 1 through 6, 1970 through 1975 . . . . . . . . . . . . . . . . . . . . . | 28 |
| 8 | Relative chloride concentrations for Spring 1975. Contours were drawn for data taken on four separate dates. On each date the highest concentration was assigned a value of 1.0 and all others calculated as a decimal fraction of the highest value . . . . . . . . . . . . . . | 30 |
| 9 | Mean seasonal chloride concentrations (1970 through 1974) at lake Stations 1 through 6 compared to seasonal Detroit River chloride mean . . . . . . . . . . . . . . . . . . | 34 |
| 10 | Chloride profiles for the Detroit River at Range 3.9, comparing data from the Michigan and Ontario Water Resources Commissions. Percentage figures represent the proportion of cross-sectional flow . . . . . . . . . . | 36 |

Figure | | Page

11 Total nitrogen concentrations at lake stations 1 through 6, 1970 through 1975 . . . . . . . . . . . . . . . . . . . 40

12 Nitrate nitrogen concentrations at lake stations 1 through 6, 1970 through 1975 . . . . . . . . . . . . . . . . . . . 41

13 Ammonia nitrogen concentrations at lake stations 1 through 6, 1970 through 1975 . . . . . . . . . . . . . . . . . . . 42

14 Organic nitrogen concentrations at lake stations 1 through 6, 1970 through 1975 . . . . . . . . . . . . . . . . . . . 43

15 Plots of relative nitrate, organic, and ammonia nitrogen concentration vs. relative chloride concentration for the Spring, 1975, random samples . . . . . . . . . . . . . . . . 52

# INTRODUCTION

Large steam-electric power plants with once-through cooling systems require large quantities of water to maintain their steam cycles. Where there is access to large bodies of water, once-through cooling is usually the most economical means of cooling; and, therefore, it is used at many power plants on the Great Lakes. Potentially, these plants may at least locally redistribute and alter influent waters of varying qualities which include such chemical elements associated with eutrophication as nitrogen. This paper describes the impact of the once-through cooling system at the Monroe Power Plant on the distribution of nitrogenous compounds along the western shore of Lake Erie.

The western basin of Lake Erie receives water from a densely populated watershed. Nitrogen may enter the lake from numerous artificial as well as natural sources. The major potential sources to the western basin are three tributaries, all of which enter the basin at the western end. By far the largest tributary, the Detroit River, carries nitrogenous waste from the city of Detroit. The second largest tributary, the Maumee River, drains nitrogen from an intensively farmed watershed and the city of Toledo. Located between these two major rivers, the smaller Raisin River contributes relatively less amount of nitrogen. However, the close proximity of the Raisin River to the power plant potentially has a disproportionate effect on the local distribution of nitrogen.

The effects of any environmental alterations produced by a power plant or any other source are difficult to separate from natural and artificial background variation without some knowledge of local hydrodynamics. Measurement of the impact on the local coastal zone requires knowledge of water movements through the affected area, including the usual quality of water that enters the study area. The relative impacts on water quality can not be assessed without differentiating the effects of the various sources of water on the area concerned.

Data collected over a five year period (1970-1975) show the relative impact of the Monroe Power Plant and the Detroit, Maumee and Raisin Rivers on the nitrogen concentration in the Brest Bay area of western Lake Erie. The derivation of waters in the study area was traced by the relative concentrations of the chloride ion, and the relative importance of dilution was determined for the distributions of nitrate nitrogen, ammonia nitrogen and organic nitrogen. The data indicate that more than enough nitrogen enters this part of Lake Erie via tributaries to explain the observed distributions. In fact, some nitrogen may be lost from the water column as it passes through the study area although nitrogen distributions mostly reflect the mixing of tributary waters. The Monroe Power Plant enhanced the mixing of water from the Raisin River and the lake water in the vicinity but, otherwise, had little effect on nitrogen concentrations.

# DESCRIPTION OF THE STUDY AREA

## Western Basin of Lake Erie

### General Description

The study area is the western basin of Lake Erie near Detroit Edison's Monroe Power Plant at Monroe, Michigan (Figure 1). The western basin of Lake Erie covers an area of about 3000 $km^2$ which is morphologically distinguished from the rest of the lake by an archipelago that lies roughly along a line drawn from Point Pelee to Cedar Point. The mean depth of the western basin is about 7 meters and the overall mean depth of Lake Erie is about 19 meters (Beeton, 1971). The western basin receives more than 90% of the total water discharged into Lake Erie, but it comprises only about 5% of the total lake volume. Therefore, the minimum possible flushing rate for the western basin is estimated to be about two months (Beeton, 1961) while that for the entire lake is estimated to be about three years (Beeton, 1971). Because of the relatively rapid flushing of the western basin, its water quality depends primarily on the input from the tributaries.

In the western basin, the temperature is moderated through the heat capacity of the lake; summer heating and autumn cooling are delayed with respect to the air temperature. Cole (1973) showed that the temperature regime in the near shore lake study area reached a

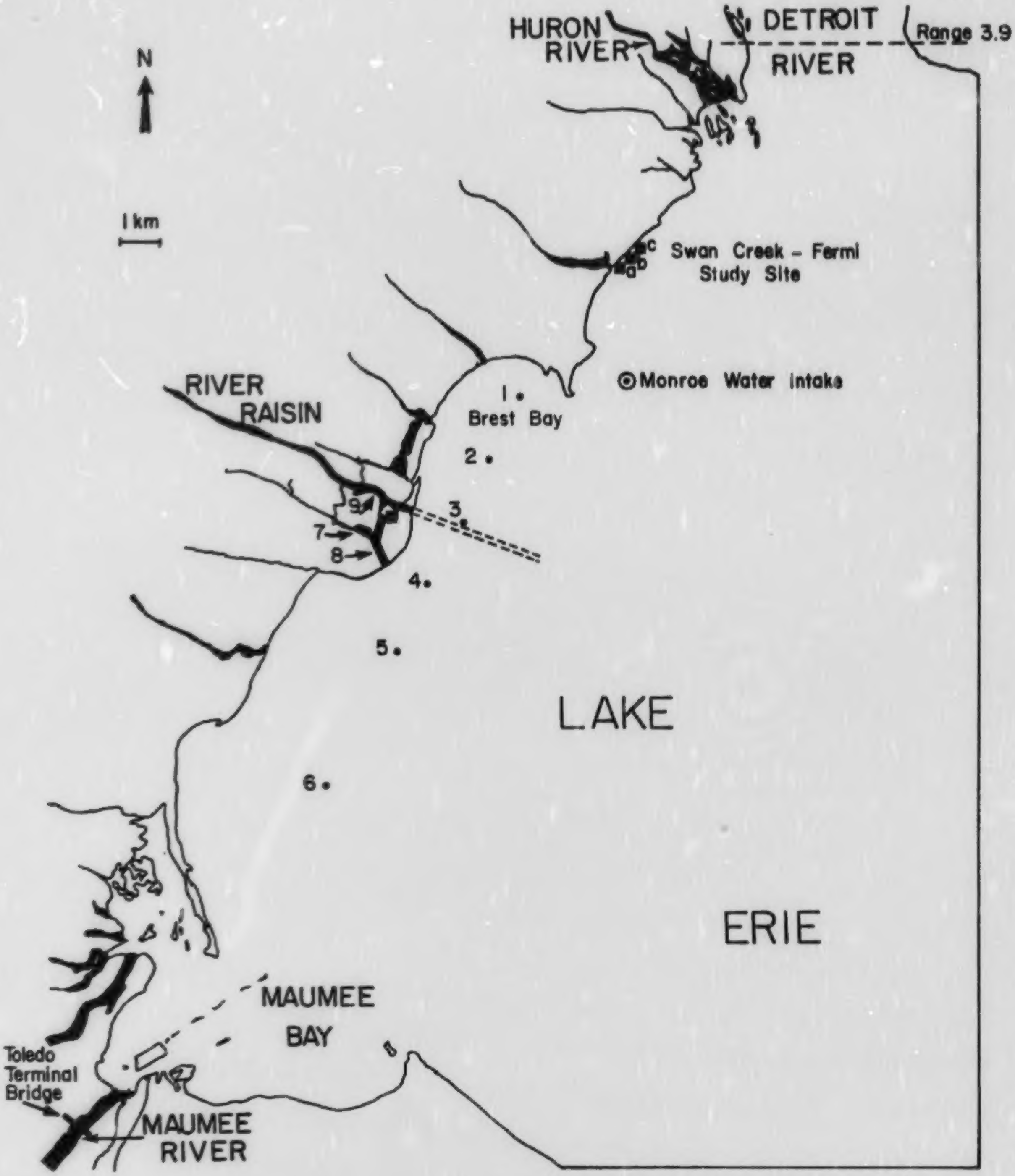

HURON RIVER
DETROIT RIVER
Range 3.9
N
1 km
c
b
a
Swan Creek - Fermi Study Site
Monroe Water intake
RIVER RAISIN
1.
Brest Bay
2.
3.
9
7
8
4.
5.
LAKE
6.
ERIE
MAUMEE BAY
Toledo Terminal Bridge
MAUMEE RIVER

Figure 1. Map showing the location of sampling sites in the western basin where chloride and nitrogen concentrations were measured.

minimum of 1°C in January 1971 and 1972 and a maximum of 24°C in the summers of 1970, 1971 and 1972. The mean annual air temperature is about 10°C (50°F). The shallow western basin is generally vertically homogeneous both thermally and chemically due to the action of wind and seiche, but temporary stratification can occur under the proper conditions (Carr et al., 1965).

Rainfall in the area has a long term average of about 73.7 cm (29 in.) per year. Precipitation for the calendar years 1970 through 1974 at Monroe, Michigan, averaged 73.4 cm (28.9 in.) with a minimum of 57.2 cm (22.5 in.) in 1971 and a maximum of 82.6 cm (32.5 in.) in 1973 (U. S. Weather Service). Precipitation is well distributed throughout the year, but the minimum usually occurs in February.

The prevailing winds are from the southwest and blow from that direction approximately 23% of the time (Anon., 1965), and the monthly resultant wind is nearly always from the southwest (Figure 2).

## Hydrodynamics

The largest single inflow of water to the western basin is the Detroit River which contributes about 95% of the annual input. The flow is relatively uniform over the year (Figure 3) and is determined by the relative heights of Lake Huron, Lake Erie, and their connecting waterways.

The Maumee River contributes about 2.5% of the water discharged into the western basin while the Raisin River adds less than 0.5%. Both rivers have pronounced annual cycles with maxima occurring in spring and minima in late summer (Figures 3 and 4). The river flow is not correlated directly with precipitation because of the impact

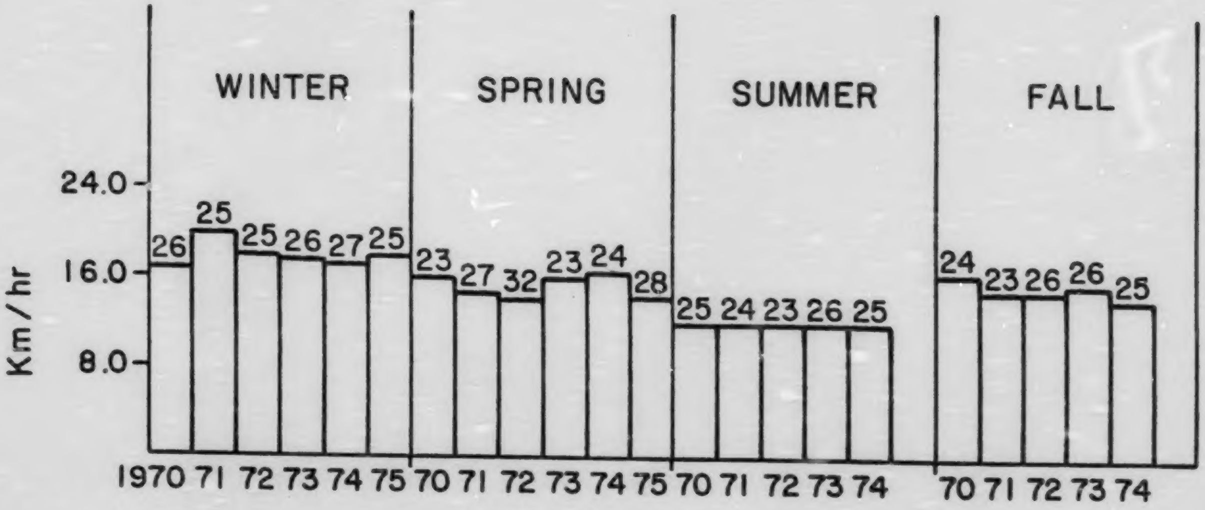


Figure 2. Resultant wind direction in tens of degrees and wind speed in km/hr during the study period.

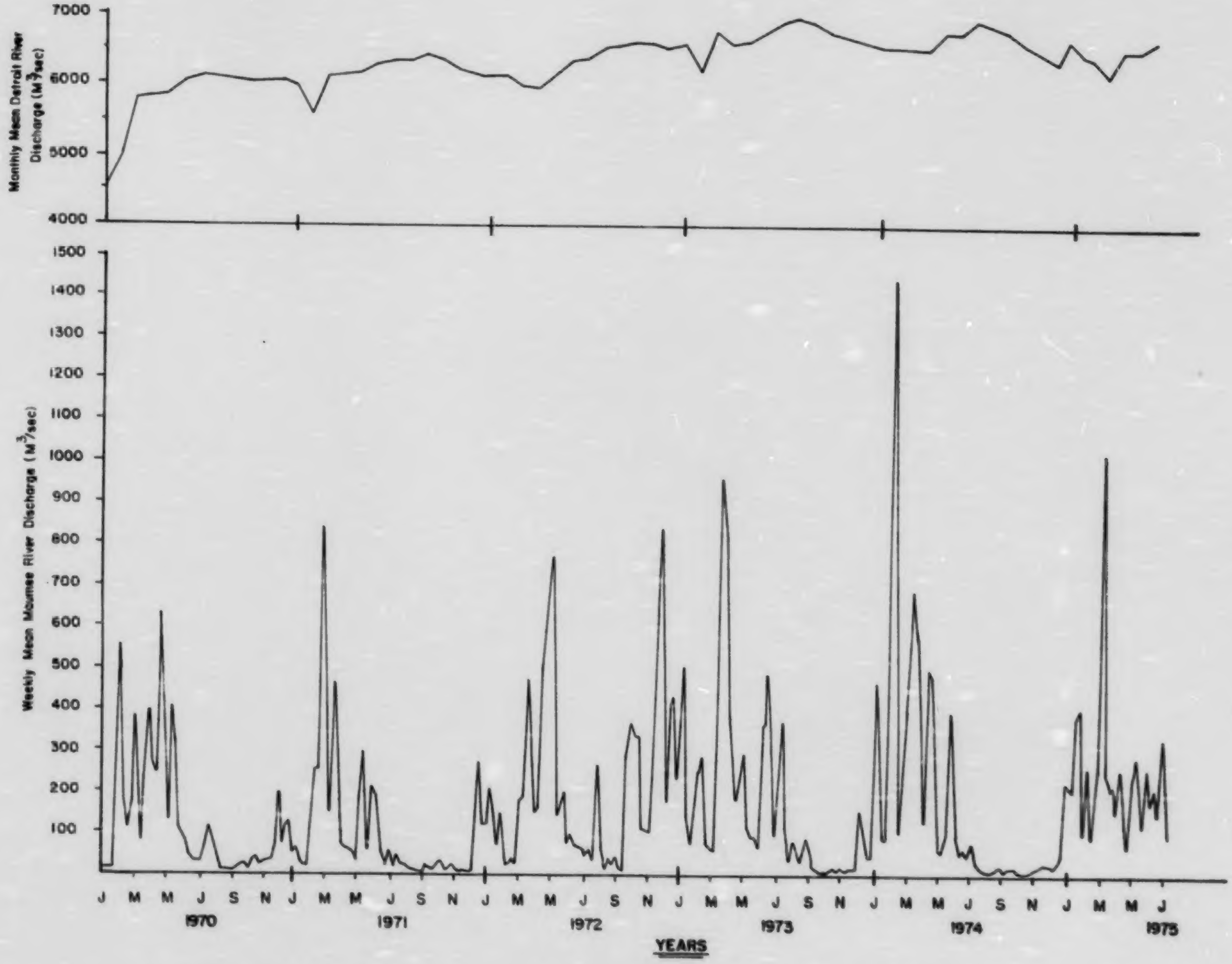


Figure 3. Monthly Detroit River discharge and weekly discharge of the Maumee River.

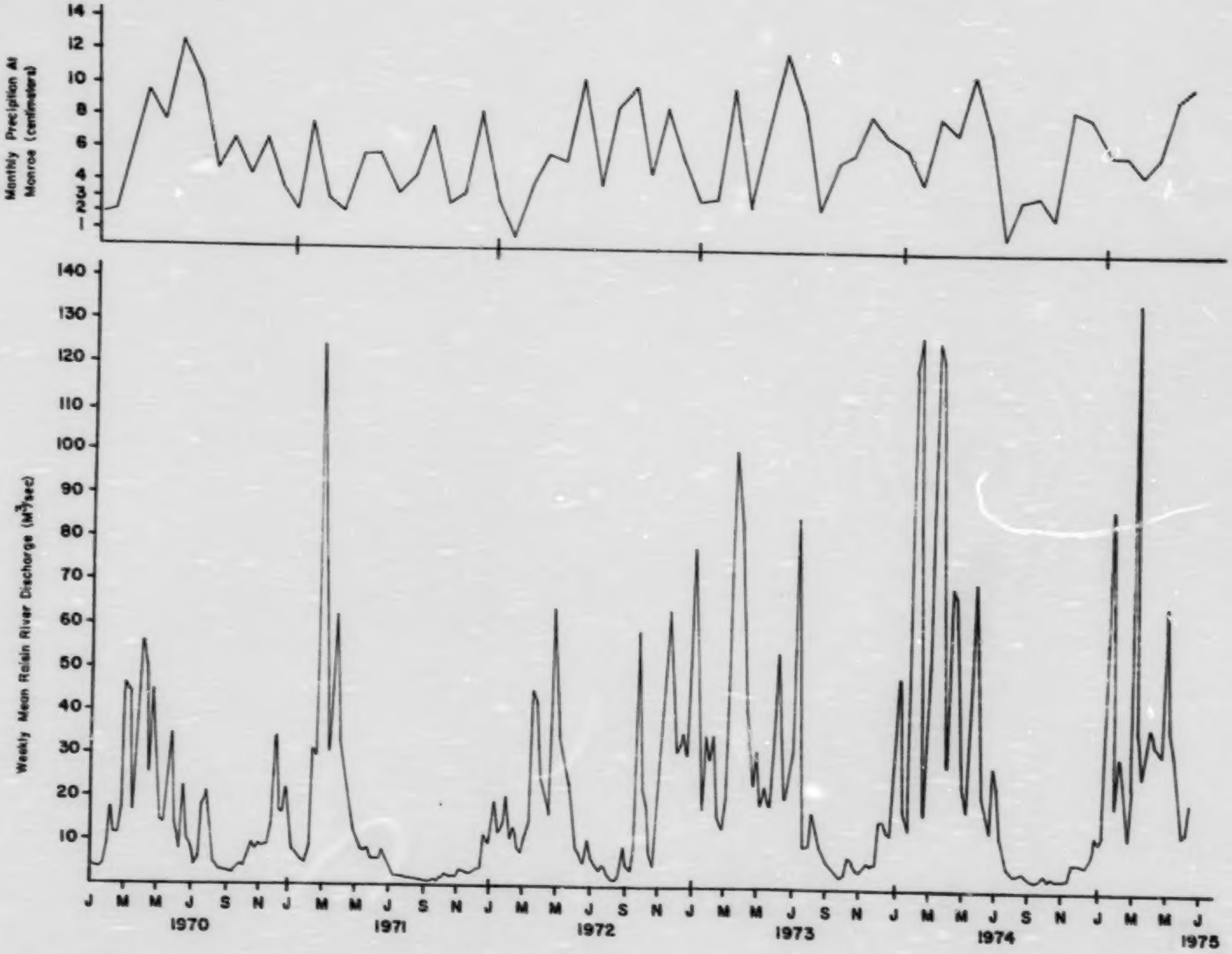


Figure 4. Weekly Raisin River discharge and monthly precipitation at Monroe, Michigan.

of other seasonal factors (Figure 4). Discharge rate means and extremes for the three rivers are given in Table 1. Langlois (1954) believes that the input of all other tributaries to the western basin occasionally exceeds that of the Detroit River during so-called "freshet" periods.

Circulation in the western basin of Lake Erie was previously investigated by Olsen (1950), Verber (1955), Herdendorf (1969), Kovacik (1972), and the Public Health Service (1965). Their models allowed broad predictions of water mass movements in the near shore area. In general, a large part of the inflow from the Detroit River passes directly into the central basin of Lake Erie via Pelee passage. But Kovacik (1972) and Walters et al. (1972) show that some Detroit River water reaches the southern shore with relative chemical and physical integrity. This southward flowing Detroit River water, combined with the northward flowing input from the Maumee River, tends to form a large clockwise gyre in the southwestern corner of the western basin. Day to day variations in these currents are pronounced because of such contributing factors as the changing hydraulic loadings and changing winds.

Verber (1953), Olsen (1950), Andrews (1948), and O'Leary (1966) reported that surface water currents tend to directly follow the wind. Results in western Lake Erie (Olsen, 1950; Hartly, 1968) tend to support the assumption that bottom currents in shallow water follow the same general circulation as surface currents. Cole (1972) estimated mean monthly water velocities based on locally measured wind driven currents along the western shore for 1970. Those estimates indicated that the prevailing monthly resultant current was northward

Table 1. Mean, maximum, and minimum discharges of the Detroit, Maumee, and Raisin Rivers.

| | Mean Discharge $m^3$/sec (% of Detroit River) | Maximum Monthly Discharge -- $m^3$/sec (% of Detroit River) | Maximum Daily Discharge $m^3$/sec (% of Detroit River) | Minimum Monthly Discharge -- $m^3$/sec (% of Detroit River) | Minimum Daily Discharge -- $m^3$/sec (% of Detroit River) |
|---|---|---|---|---|---|
| Raisin River | | | | | |
| 1970 | 16.2 (0.28) | 41.9 (0.72) Apr | 90.3 (1.56) 7 Mar | 3.28 (0.05) Sept | 2.27 (0.04) 14-15 Sept |
| 1971 | 12.4 (0.20) | 51.3 (0.91) Feb | 154.0 (2.75) 23 Feb | 1.42 (0.02) Aug | 0.99 (0.02) 3 Sept |
| 1972 | 20.4 (0.32) | 46.4 (0.70) Nov | 101.4 (1.54) 19 Sept | 4.45 (0.07) July | 3.11 (0.05) 1-7 Aug |
| 1973 | 26.1 (0.39) | 77.4 (1.14) Mar | 145.6 (2.10) 3 July | 4.08 (0.06) Sept | 3.11 (0.04) 19 Sept |
| 1974 | 27.3 (0.41) | 77.3 (1.17) Mar | 198.2 (3.00) 9 Mar | 3.14 (0.05) Sept | 2.52 (0.04) 30 Aug and 1 Sept |
| Maumee River | | | | | |
| 1970 | 129.9 (2.24) | 413.7 ( 7.09) Apr | 942.9 (16.16) 21 Apr | 14.5 (0.24) Sept | 3.23 (0.05) 12 Sept |
| 1971 | 101.8 (1.64) | 395.3 (15.79) Feb | 1101.5 (19.65) 22 Feb | 9.7 (0.15) Aug | 4.81 (0.07) 31 Aug |
| 1972 | 214.8 (3.37) | 530.9 ( 8.01) Nov | 1328.1 (22.12) 23 Apr | 30.6 (0.47) Aug | 8.27 (0.13) 9 Sept |
| 1973 | 174.5 (2.59) | 575.7 ( 8.47) Mar | 1129.8 (16.91) 28 Dec | 10.1 (0.15) Sept | 3.96 (0.06) 25 Sept |
| 1974 | 170.0 (2.45) | 562.9 ( 8.53) Jan | 1990.7 (30.17) 22 Jan | 12.7 (0.19) Aug | 4.87 (0.07) 8 Oct |
| Detroit River | | | | | |
| 1970 | 5800 | 6140 July | -- | 4530 Jan | -- |
| 1971 | 6200 | 6460 Aug | -- | 5610 Feb | -- |
| 1972 | 6370 | 6650 Oct | -- | 6000 Apr | -- |
| 1973 | 6740 | 6990 Aug | -- | 6230 Feb | -- |
| 1974 | 6680 | 6970 July | -- | 6370 Nov | -- |

along the west shore. Verber (1955) presents evidence that the longitudinal seiche of Lake Erie is a major contributing factor to these water movements. As the water rises and falls, it has a net westward movement south of Pelee Island and a clockwise progression around the western basin. Seiches can create pulses in the discharge of the Detroit River (Herdendorf, 1969); and, at times, have been able to briefly reverse its flow (Langlois, 1954).

## Water Quality

Both phytoplanktonic (Davis, 1964) and chemical (Verduin, 1969) data indicate that Lake Erie is eutrophic. The water quality of the western basin is particularly sensitive to the impact of its influent waters because of its short flushing time. The qualities of these influent rivers differ enough to plot the movement of water by physical and chemical measurements (Herdendorf, 1969; Walters *et al*., 1972; Kovacik, 1972; Andrews, 1948). Water quality in the western basin is determined basically by the biggest contributor, the Detroit River. Compared with the smaller tributaries in the watershed, the Detroit River has lower conductivity, temperature, and concentrations of chloride and alkalinity. The Detroit River has been described (Harlow, 1966) as a major supplier of nitrogen and phosphorus to Lake Erie because of its massive discharge. However, the Maumee River has an impact much greater than indicated by discharge alone. According to FWPCA (1968) estimates, the Maumee contributed 25% of the phosphorus and 38% of the total BOD that entered the basin during the 1960's. The impact of the Maumee River has been determined by Curl (1957) who described the high phosphorus loading, Chandler and

Weeks (1945) who noted the nitrogen inputs, and Verduin (1964) who described the high silt loadings. Verduin further states that the high silt loadings, combined with increased phosphorus loading, is primarily responsible for the eutrophic state of Lake Erie today.

The Raisin River is the smallest of the tributaries discussed here, but it nevertheless has a strong local impact on the study area (Carr and Hiltunen, 1965; Cole, 1972). Besides draining a large agricultural area, the Raisin River receives both municipal and industrial effluent including that from paper mills. The Raisin is reported to have experienced anoxic conditions during summer and fall as early as 1929 (Wright et al., 1955). Recent improvements in municipal and industrial wastewater treatment may be reversing that effect.

## The Monroe Power Plant

In 1967 the Detroit Edison Company began building a 3200 megawatt coal fueled power plant on a filled portion of the Raisin River delta. The intake for cooling water was sited on the Raisin River (Figures 1 and 5) within a kilometer of the river mouth. A discharge canal was constructed to be approximately 2.6 kilometers long and 150 meters wide. It empties into Lake Erie about 3.5 kilometers southwest of the mouth of the Raisin River.

The design allows the plant to pump cooling water from the Raisin River to condense steam from turbine operation with subsequent discharge of the heated water into the canal. When the river discharge was less than the plant pumped, water from Lake Erie would provide the difference by inflow via the Raisin River mouth.

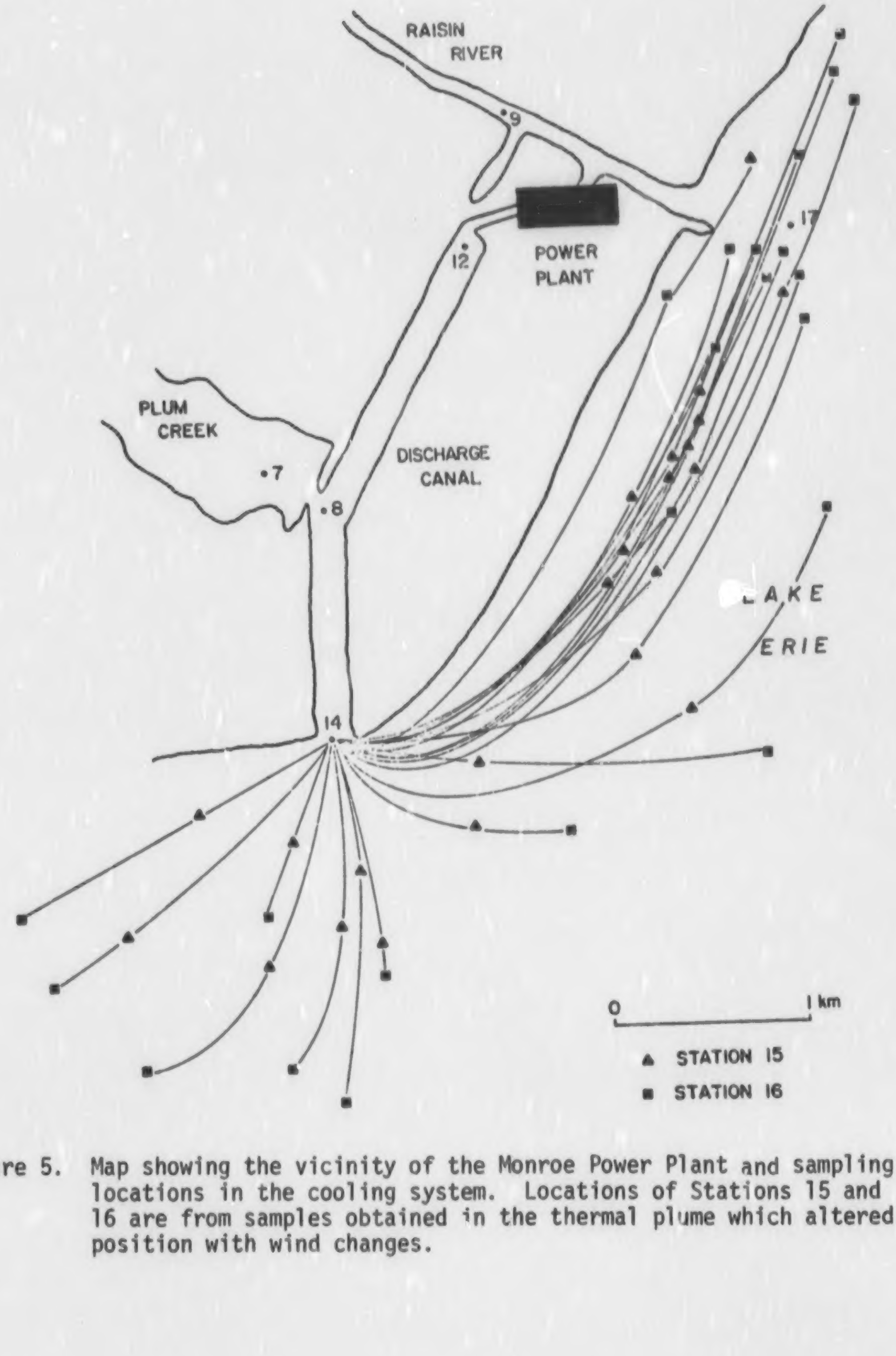

RAISIN RIVER
9
POWER PLANT
12
17
PLUM CREEK
7
8
DISCHARGE CANAL
LAKE ERIE
14
0
1 km
▲ STATION 15
■ STATION 16

Figure 5. Map showing the vicinity of the Monroe Power Plant and sampling locations in the cooling system. Locations of Stations 15 and 16 are from samples obtained in the thermal plume which altered position with wind changes.

Four 800 megawatt power units were built and brought into operation at a rate of about one unit per year between May, 1971 and May, 1974. Three cooling pumps circulated the cooling water for each unit. Each pump is rated at approximately 7 $m^3$/second, with a maximum pumping rate of approximately 84 $m^3$/second for all four units. In 1971 and 1972, power was generated very sporadically as the plant experienced numerous shut-downs due to testing, maintenance, and various mechanical adjustments. Cooling water was pumped more consistently than power was produced, but pumping averaged slightly less than 21 $m^3$/second (three pumps) for the balance of 1971. In May of 1972, the second power unit began pumping followed by the additional units in October, 1972 and September, 1973. The operation of the pumps preceeded the initiation of power production in each unit.

Because of intermittant operation, the average pumping for 1972 was only 29 $m^3$/second while the means for 1973, 1974, and the first half of 1975 were 50, 54, and 55 $m^3$/second, respectively. Pumping rates in the future are expected to average higher as power production becomes uniformly greater. The most cooling water was pumped in the summers of 1974 and 1975. Conversely, in the 1974-75 winter pumping was decreased from maximum because of the cooler ambient temperature. In addition, winter pumping is decreased relative to the discharge canal because some of the discharge water is routed back to the river to maintain an ice-free intake.

When the river flow was high in winter or spring, the discharge water could consist almost entirely of river water; but at times of low river flow, such as in late summer and fall, almost all the water came from the lake. Whenever plant pumping exceeded river discharge, essentially all of the river water passed through the plant.

## Sampling Locations

### The Detroit Edison Sites

Studies of the water samples from the Detroit Edison sampling sites (Figures 1 and 5) were supported by the Detroit Edison Company. The sites consist of stations in the power plant cooling system and in Lake Erie. The lake stations were sampled from 1970 through mid-1975 to identify the effects of the plant effluent on water masses as they followed a generally northern course from station 6 to station 1 (shown in Figure 1). Sampling stations 9, 8, and 7 were respectively located in the Raisin River, the power plant discharge canal, and a shallow embayment (Plum Creek) which adjoins the discharge canal. Lake stations 1 to 6 were approximately 1.5 to 2 kilometers from shore and 1.5 kilometers apart except for station 6 which was approximately 3.5 kilometers from shore and 5.5 kilometers SSW of station 5. The depths at these lake stations ranged from 4 to 6 meters. Plum Creek (station 7) is shallow (less than two meters) and discharges less than 1 $m^3$/second into the discharge canal. The discharge canal itself (station 8) is 6 to 7 meters deep, approximately 150 meters wide and 2.6 kilometers long. Station 9 is located in the Raisin River, upstream from the power plant intake.

Samples were collected from stations 1 to 9 on a biweekly basis, weather permitting, from May 7, 1970 to June 24, 1975. Generally unfavorable weather conditions precluded all except sporadic sampling from November through March of each year. The samples were collected with an eight liter Van Dorn bottle in triplicate at two depths (0.5 and 2.5 meters) at eight stations and at only the 0.5 depth in Plum Creek, station 7.

Samples for nitrogen analyses were placed in polyethylene bottles and preserved with 42 milligrams per liter (mg/liter) of mercuric chloride (Howe and Holly, 1969). Samples to be analyzed for chloride remained unpreserved. The water bottles were returned to MSU for analysis.

In the spring of 1975, stations 1, 2, 4, 5 and 7 were not sampled although sampling continued at stations 3, 6, 8 and 9. In addition, 16 stations were randomly selected from a grid superimposed on a map of the sampling area (Figure 6). Half of the samples were taken from an area which was periodically warmed by the discharge plume of the power plant, and the other half came from the adjacent waters beyond the direct influence of the plume.

## The U.S.E.P.A. Sites

A three year study on entrainment effects of the cooling system was undertaken in November, 1972, with a grant from the United States Environmental Protection Agency (USEPA). Seven stations were chosen (Figure 5) to sample the river (station 9) and lake (station 17) as sources of cooling water as well as to follow its course through the discharge canal (stations 12, 8, and 14). In addition, two plume stations (stations 15 and 16) were sampled in order to trace the progress of the discharge water as it mixed with the lake. Station 15

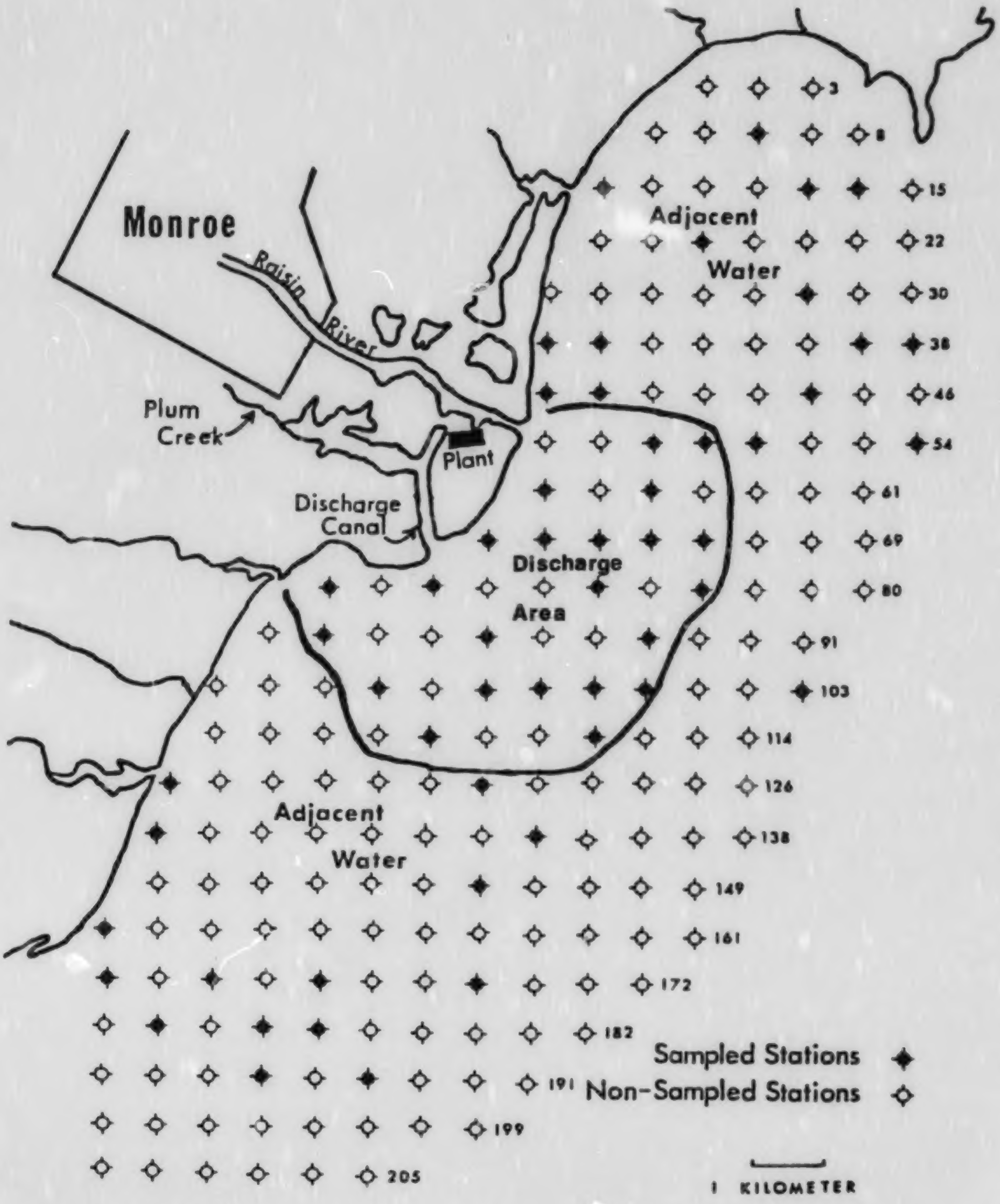

Monroe
Raisin River
Plum Creek
Plant
Discharge Canal
Discharge Area
Adjacent Water
Adjacent Water
3
8
15
22
30
38
46
54
61
69
80
91
103
114
126
138
149
161
172
182
191
199
205
Sampled Stations ◆
Non-Sampled Stations ◇
1 KILOMETER

Figure 6. Map showing the location of the 1975 random sampling sites.

was sampled along the main axis of the plume where the temperature had fallen half way from the discharge canal temperature to the ambient lake temperature. Station 16 was also sampled along the main axis of the plume but in a position where the temperature was only 1 to 2°C above ambient lake temperature. Therefore, stations 15 and 16 changed position in response to wind driven currents as well as power plant discharge. Figure 5 shows the positions of stations 15 and 16 during the first year of the study. Station 18 was an artificial station whose composition was calculated on the basis of the Raisin River discharge and plant pumping rates. It was assumed that only river water was drawn into the intake until plant pumping exceeded river discharge, when additional water was drawn from Lake Erie via the Raisin River mouth.

At each station, five replicates were taken by random sampling at five depths except at stations 15 and 16 where samples were all from just below the surface. Sampling was carried out on a bimonthly basis from November, 1972, to September, 1975. Each set of samples included a mercury (II) preserved set for nitrogen analysis and three sets of unpreserved samples for chloride analysis, each designed to sample one of the periods: morning, afternoon, and evening. These three sets were taken over a two or three day period while the nitrogen samples were taken at the same time as one of the chloride sets.

## Other Data Sources

Chloride data were obtained from the Monroe Water Treatment plant for the days on which the study area was sampled (W. LePage, personal communication). The intake is located 1.5 kilometers west of Stony Point (Figure 1). Chloride data were also obtained from near shore stations at the Swan Creek-Fermi study site (Figure 1) during 1973. Shaffer (1975) sampled at the stations in triplicate on six dates during the year.

Chemical data for the Detroit River were obtained from two agencies. Sampling was conducted across the mouth of the Detroit River along a transect referred to as Range 3.9 (Figure 1). The Ontario Water Resources Commission (OWRC) reported chloride and inorganic nitrogen concentrations for 1971. The Michigan Water Resources Commission (MWRC) reported chloride and inorganic nitrogen concentrations for the period 1970 through 1974. Both agencies sampled about six times a year during the ice-free season.

Chloride and inorganic nitrogen concentrations in the Maumee River were obtained from the Toledo Pollution Control Agency (TPCA) for the years 1970 through 1974. Samples were taken from the west bank of the river at the Toledo Terminal Bridge (Figure 1), approximately 1.5 kilometers from the river mouth, on a monthly basis. Additional chloride data for the Maumee River were obtained from the U. S. Geological Survey. Chloride values were taken bimonthly at Waterville, Ohio, approximately 34 kilometers from the mouth of the river.

Daily discharge values of the Raisin and Maumee Rivers were obtained from the State Offices of the U. S. Geological Survey. Monthly discharge values for the Detroit River were obtained from the Lake Survey Office of the U. S. Corps of Engineers.

Wind information was obtained from the U. S. Weather Service office at East Lansing for the Toledo Express Airport. Monthly precipitation values were also obtained for Monroe, Michigan, from this office.

## METHODS AND MATERIALS

Laboratory analyses were carried out for chloride, total Kjeldahl nitrogen, nitrate nitrogen, ammonia nitrogen, and nitrite nitrogen. Chloride analyses were accomplished with mercuric nitrate titration of a 25 milliliter sample to the diphenylcarbazone-mercury complex endpoint. A mixed indicator containing Xylene cyanol FF was used, as outlined in Standard Methods (Anon., 1965).

Total Kjeldahl nitrogen was measured by digesting a 50 ml sample with a mercury catalyst. Ammonia formed in the digestion of nitrogen-containing organic compounds and nitrogen already present as ammonia were then distilled and determined by the Nesslerization reaction. The micro-Kjeldahl method that was followed was outlined in Standard Methods (Anon., 1965) and in the FWPCA (Anon., 1969) and EPA (Anon., 1971) manuals.

Nitrate nitrogen was determined by the method of Jenkins and Medsker (1964), slightly modified in EPA Methods (Anon., 1971) by elimination of the chloride masking reagent. Samples containing more than the maximum standard of 0.7 mg/liter had to be diluted to within the standard range.

Ammonia nitrogen analyses were carried out via distillation and Nesslerization. Originally, the distillation pH was buffered at 7.4 (Anon., 1965) but it was changed to 9.5 (Anon., 1969) to reduce the possibility of any hydrolysis of nitrogen-containing organic compounds.

In 1972 the method for ammonia nitrogen was changed to the phenate method of Harwood and Kuhn (1970). This method eliminated the distillation step completely, was easier and faster to perform, and was more precise than previous methods. Although the ammonia analysis method was changed to insure against error, no significant differences were detected between methods when they were tested with samples from the study area.

Nitrite analyses were carried out with a method similar to the one provided in Standard Methods (Anon., 1965) except that acetic acid alone was added as a pH control, instead of an acetate buffer. The nitrite analyses were discontinued in 1970 because the values were usually insignificant ($<0.01$ mg/liter).

Organic nitrogen was calculated as the difference between total Kjeldahl nitrogen and ammonia nitrogen. Inorganic nitrogen was calculated as the sum of ammonia nitrogen and nitrate nitrogen, discounting any nitrite. Total nitrogen was assumed to be the sum of nitrate nitrogen and total Kjeldahl nitrogen. This is equivalent to the organic nitrogen plus inorganic nitrogen, and it is equal to the total bound nitrogen of the sample.

Mean values for all stations on each sampling date are given in Appendix Tables A1 through A7 and seasonal means in Tables A8 through A14. Analysis of variance tests were performed on each date through the 1972 sampling year. Where station differences were significant ($p < 0.05$), Tukey's multiple range test (Steele and Torrie, 1960) was performed, and significance ($p < 0.05$) was indicated by underlining. Where significant ($p < 0.05$) depth differences were present, a dagger (†) was placed next to the date. Asterisks (*) next to a station number denote that insufficient replicates were available to include that station in the analysis of variance model. However, the value is included for comparison. After 1972, the analysis of variance was discontinued.

# RESULTS AND DISCUSSION

## Chloride and Hydrodynamics

Only negligible fractions of the chloride concentrations in the Great Lakes are influenced by chemical reactions of either physical or biological origins. Therefore, the chloride concentrations may be used effectively to trace the movements and mixing of different water masses (Hem, 1970; Kaufman and Orlob, 1956; Spain and Andrews, 1970; Ketchum, 1951 and 1967). A mass balance calculation is used, and if the chloride concentrations of all sources are known, then the relative proportions of each source are easily calculated (Hem, 1970). The value of chloride as a tracer is limited by the degree of difference in concentrations between sources, and by the temporal variability of each source. The conditions are best when the sources are of widely differing and constant concentrations. Chloride concentrations in the study area are characterized by wide differences among waters in the lake near the Monroe power plant, the Detroit River, and the similar Maumee and Raisin Rivers (Table 2). Concentrations in the Maumee and Raisin Rivers consistently averaged about two times the concentration in the lake from 1970 to 1974 and more than twice the concentrations reported for the Detroit River. Data presented in Table 2 show that the lake concentrations most strongly reflect the input of Detroit River water even though the Maumee and Raisin Rivers are relatively close to the lake stations that were sampled.

Table 2. Seasonal and annual mean chloride concentrations at selected sites in Lake Erie and its tributaries.

| Season | 1970 | 1972 | 1973 | 1974 | Seasonal Mean |
|---|---|---|---|---|---|
| Spring | | | | | |
| Lake Mean (Stations 1-6) | 20.2 | 22.3 | 17.5 | 19.3 | 19.8 |
| Detroit River | 20.9 | 15.3 | 14.0 | 16.2 | 16.6 |
| Maumee River | 27.0 | 37.5 | 33.7 | 35.3 | 33.4 |
| Raisin River | 28.6 | 41.5 | 28.9 | 29.8 | 32.2 |
| Monroe Treatment Plant | 19.0 | 18.8 | 16.0 | 15.5 | 17.3 |
| Swan Creek-Fermi Site | -- | -- | 16.8 | -- | 16.8 |
| Summer | | | | | |
| Lake Mean (Stations 1-6) | 24.2 | 16.7 | 16.3 | 18.2 | 18.9 |
| Detroit River | 18.5 | 15.2 | 16.9 | 13.2 | 16.0 |
| Maumee River | 31.0 | 32.0 | 29.5 | 44.5 | 33.6 |
| Raisin River | 33.8 | 39.7 | 36.8 | 42.5 | 38.1 |
| Monroe Treatment Plant | 19.2 | 15.0 | 14.4 | 14.0 | 15.7 |
| Swan Creek-Fermi Site | -- | -- | 15.4 | -- | 15.4 |
| Fall | | | | | |
| Lake Mean (Stations 1-6) | 21.8 | 16.8 | 14.7 | 15.2 | 17.1 |
| Detroit River | 11.8 | 14.5 | 17.3 | 13.7 | 14.4 |
| Maumee River | 47.0 | 26.3 | 55.3 | 58.5 | 46.8 |
| Raisin River | 33.6 | 41.4 | 34.7 | 34.1 | 36.0 |
| Monroe Treatment Plant | 22.0 | 17.4 | 15.0 | 15.5 | 17.5 |
| Swan Creek-Fermi Site | -- | -- | 21.1 | -- | 21.1 |

Table 2. (con't.)

| Season | 1970 | 1972 | 1973 | 1974 | Seasonal Mean |
|---|---|---|---|---|---|
| Annual Mean | | | | | |
| Lake Mean (Stations 1-6) | 22.1 | 18.6 | 16.2 | 17.6 | 18.6 |
| Detroit River | 17.1 | 15.0 | 16.1 | 14.4 | 15.7 |
| Maumee River | 35.0 | 31.9 | 39.5 | 46.1 | 37.9 |
| Raisin River | 32.0 | 40.9 | 33.5 | 35.5 | 35.4 |
| Monroe Treatment Plant | 20.1 | 17.1 | 15.1 | 15.0 | 16.8 |
| Swan Creek-Fermi Site | -- | -- | 17.8 | -- | 17.8 |

Chloride concentrations at the lake stations varied widely over the study period from 1970 to 1974 (Figure 7). The differences in chloride concentrations at station 1 through 6 in the study area were frequently significant ($p < 0.05$) on any one particular date, but the differences were not particularly consistent from one sampling date to another. This inconsistency could have resulted from the changing chloride concentrations introduced to the lake from the tributaries and other sources as well as by a changing composition caused by mass movements of water. Figure 7 indicates that early spring chloride concentrations in the lake tend to exceed those at other times of the year, but the seasonal variations are not marked. During the high spring runoff, chloride residuals from winter street saltings may contribute to higher concentrations in the lake.

Part of the seasonal variability in lake chloride concentrations may result from the relative variability of annual inputs of water from the Detroit, Maumee and Raisin Rivers (Figures 3 and 4). These three tributaries contribute almost 99% of the flow to the western basin of Lake Erie while most of the remainder flows in from the Huron River near the mouth of the Detroit River. The Detroit River contributes about 95% of the annual flow into the basin. However, the proportion and amount varies considerably according to the season. Although the Detroit River contributes a stable flow, particularly during the ice-free seasons, the mean monthly flow of the remaining tributaries typically varies by one order of magnitude. Although the Maumee River discharge averages only two to three percent of that from the Detroit River, it usually contributes eight to 15 percent of the winter or spring discharge and 0.2 to 0.4% of

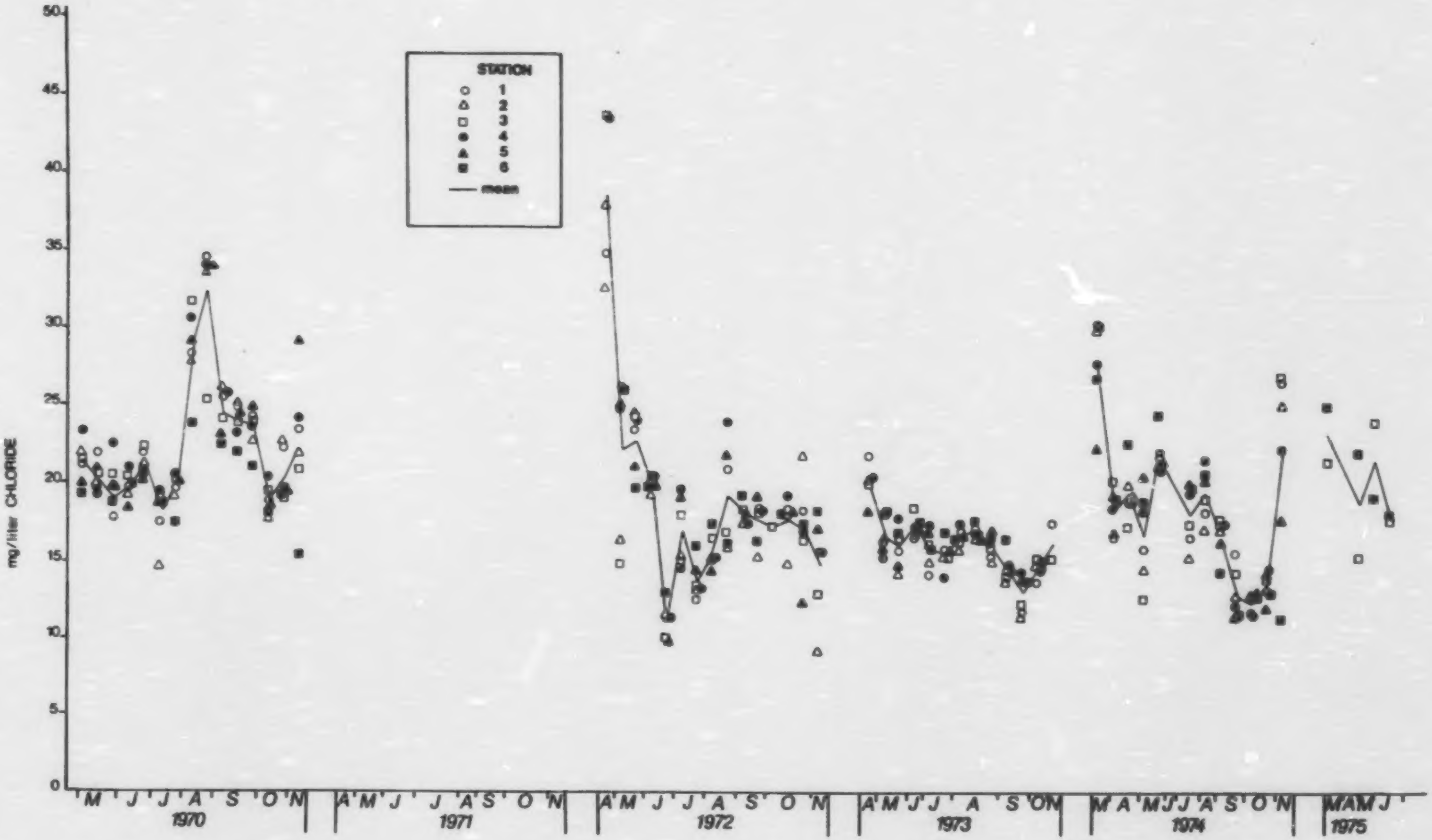


Figure 7. Chloride concentrations at lake Stations 1 through 6, 1970 through 1975.

the late summer discharge. Daily discharges from the Maumee River contributed up to 30% of the Detroit River flow during the study period.

Based on seasonal variations in discharge alone, the relative contribution of tributary flow to the lake study area could be expected to change as much as one order of magnitude from one season to the next. Nearly all of the chloride entering the study area at the western end of Lake Erie seems to be derived from these three tributaries. A small but significant contribution could come from the Huron River, but it is assumed to behave as part of the flow from the Detroit River. Other contributions of chloride may enter the western shore from tributaries other than the Maumee River or the Raisin River. The total water contributed by these other small tributaries to the study area is far less than that from the Raisin River; and their chloride concentrations probably are similar to those in the Maumee and Raisin Rivers because of the similar geology and land use patterns in their watersheds.

For the most part, small and scattered chloride inputs seem to have only local shoreline effects as indicated in Figure 8. Gradients of chloride concentrations seem strong within 0.5 kilometers of shore but become much more difficult to define off shore. In Figure 8, the relative concentration of chloride seems to be influenced by the input from the Raisin River via the discharge canal of the Monroe Power Plant and possibly from southward moving intrusions of water around Stony Point from the Detroit River area. However, the current data indicate that southward moving water with high chloride concentration is unlikely to contribute routinely to the relatively high

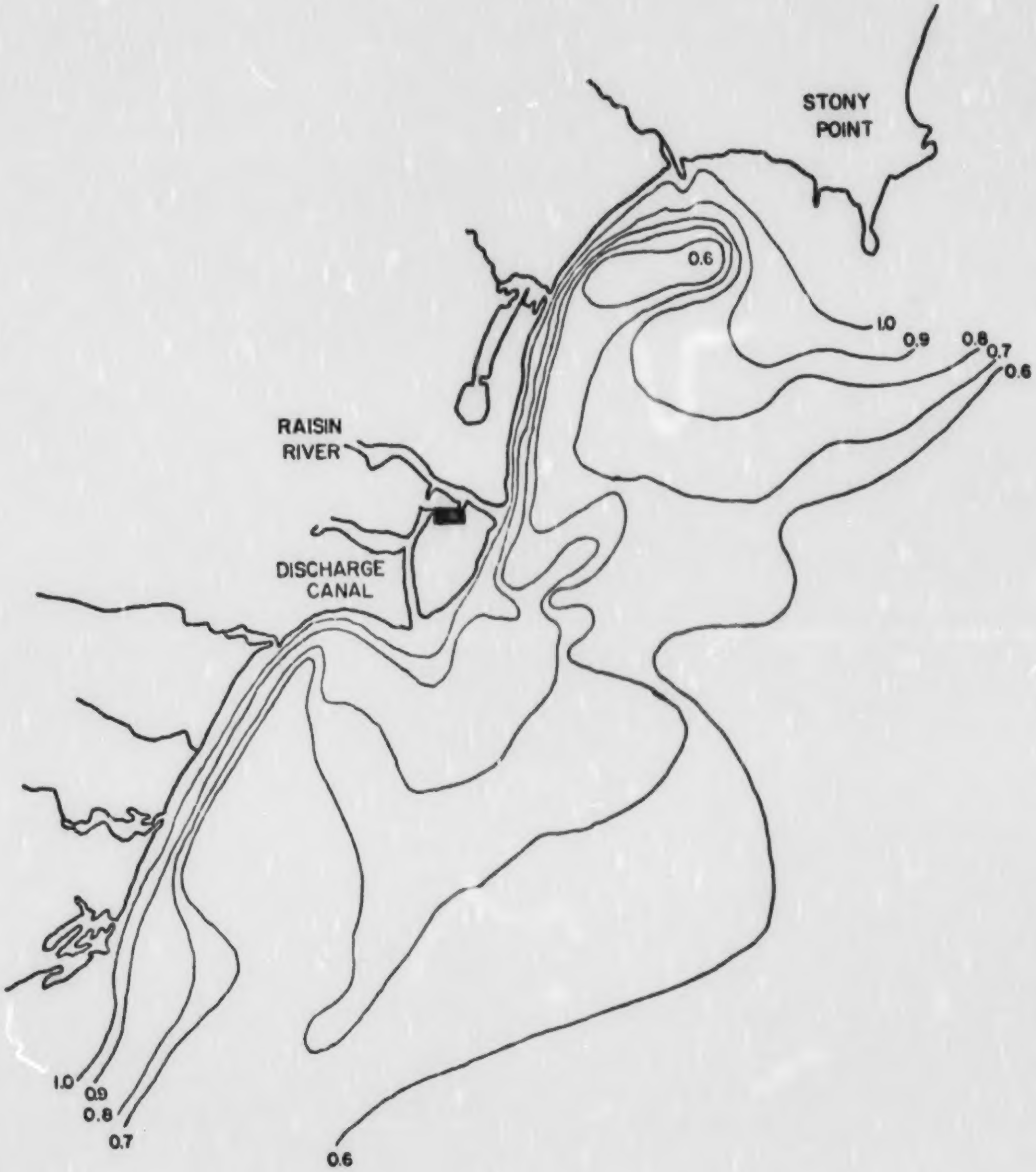

STONY POINT
0.6
1.0
0.9
0.8
0.7
0.6
RAISIN RIVER
DISCHARGE CANAL
1.0
0.9
0.8
0.7
0.6

Figure 8. Relative chloride concentrations for Spring 1975. Contours were drawn for data taken on four separate dates. On each date the highest concentration was assigned a value of 1.0 and all others calculated as a decimal fraction of the highest value.

concentrations indicated in northern Brest Bay. If so, the chloride concentrations measured at the Monroe City water intake west of Stony Point (Figure 1) and near the mouth of Swan Creek at stations a, b, and c (Figure 1), would reveal relatively high concentrations compared with those in the study area at station 1 in northern Brest Bay (Table A8). However, concentrations at these two sites typically are lower than those found at stations in northern Brest Bay (Tables 2 and A8).

Although the input of chloride from the tributaries is indicated in the relative chloride concentrations shown in Figure 8, the Raisin River waters seem to mix readily into the lake water so that even the high spring contributions appear to be indefinable within a short distance from the mouth of the discharge canal. Chloride concentrations measured in the cooling system of the Monroe Power Plant and the thermal plume in the lake also indicate that the impact of the river is very local (Table 3). The chloride concentrations were measured at the leading edge of the thermal plume along its main axis. In all instances, the relatively high chloride concentration of the Raisin River had mixed to ambient concentrations in the lake within five kilometers of the point of entry at the mouth of the discharge canal. Therefore, the impact of Raisin River water was not measurable in the lake north of station 3 or south of station 5 (see Figure 1). Chloride concentrations at stations 6, 2 and 1, therefore, varied according to the mixing of water from sources other than the Raisin River, including the Detroit and Maumee Rivers and local shoreline inputs.

Table 3. Annual mean chloride concentrations in the discharge canal and plume.

| Year | 17 | 9 | 18 | 12 | 8 | 14 | 15 | 16 | Mean and Maximum Distance from Station 16 to Station 14 Mean | Maximum |
|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | 21.4 | 29.4 | 25.1 | 25.0 | 25.5 | 25.9 | 22.5 | 20.6 | 2.6 | 4.5 |
| 1974 | 19.2 | 33.9 | 21.7 | 23.4 | 23.3 | 23.1 | 20.5 | 18.6 | --- | --- |
| 1975 | 21.3 | 32.2 | 24.0 | 26.1 | 26.4 | 26.4 | 24.8 | 23.4 | --- | --- |
| Grand Mean | 20.6 | 31.8 | 23.6 | 24.8 | 25.1 | 25.1 | 22.6 | 20.9 | | |

Previous studies of currents in the western basin, taken collectively, indicate that the wind is the primary determinant for water movements, and the currents are predominantly northward along the west shore (Andrews, 1948; Verber, 1953 and 1955; Olsen, 1950; and O'Leary, 1966). Relatively rare northeasterly winds or calm weather foster a particularly strong intrusion of Detroit River water into the study area. Brisk southerly winds enhance any effect of the Maumee River on the study area, particularly at times of high discharge. Although the wind frequently shifts, monthly resultant winds are almost always southerly. Therefore, the net water movements were expected to traverse the study area from station 5 to station 1, while in the process mixing with Raisin River water and other minor shoreline sources.

The vacillating winds cause current reversals which obscure concentration gradients, but long term averages reveal consistent trends for the relative impact of Maumee, Detroit, and Raisin River waters (Table 2). In Figure 9, it is assumed from data reported in Table A8 that Raisin River water has no influence beyond station 5 to the south or station 3 to the north. The mean rise in chloride concentration observed at stations 5, 4 and 3 is believed to have been caused entirely by the Raisin River input just west of station 4 except in 1970 when it was west of station 3. There are no other potential sources along the shore in that vicinity except the extensive human settlement on the northern shore of Brest Bay. Therefore, water at station 6 and station 2 is believed to reflect measurable mixtures of Detroit and Maumee River water, whereas station 1 may

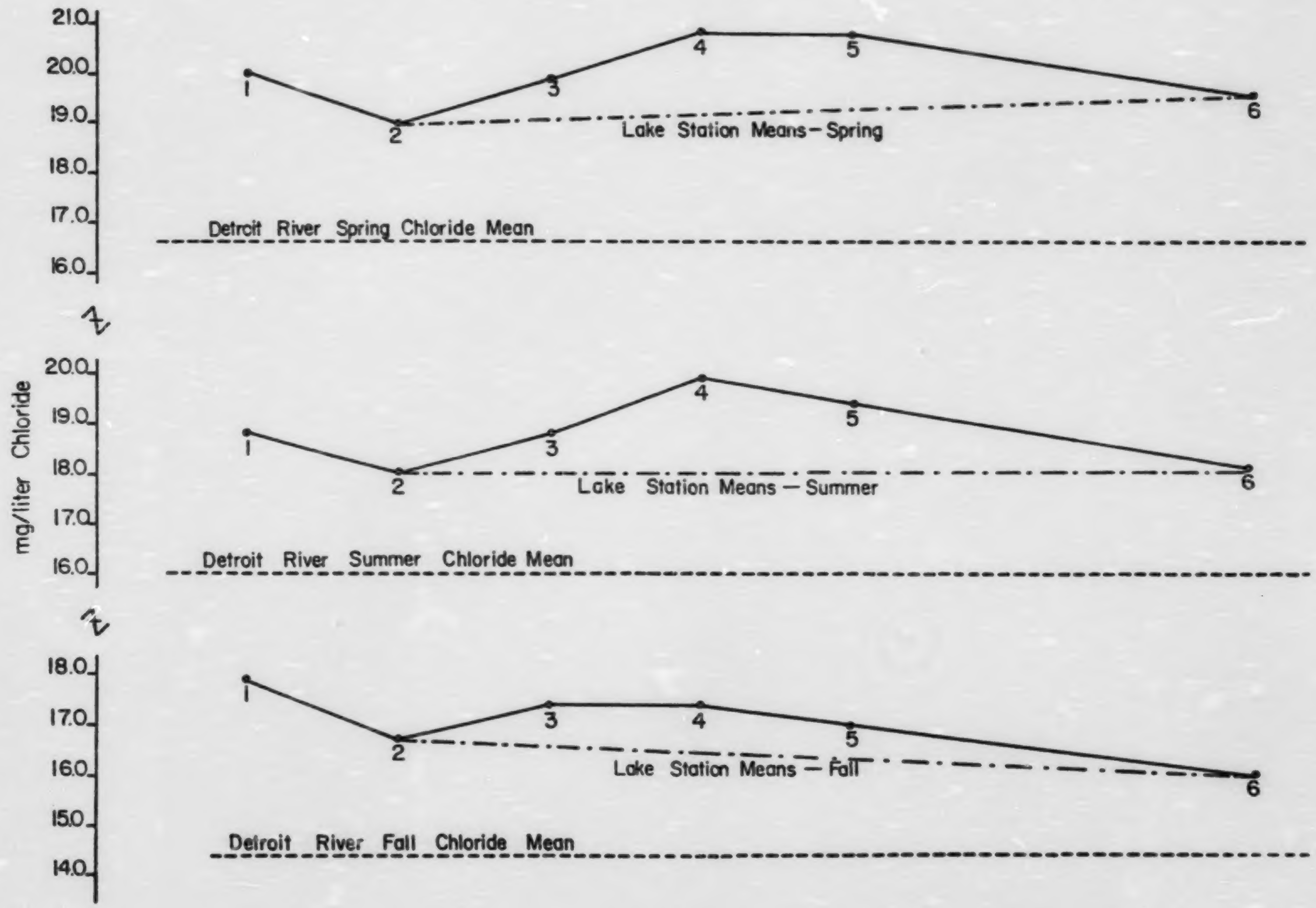


Figure 9. Mean seasonal chloride concentrations (1970 through 1974) at lake Stations 1 through 6 compared to seasonal Detroit River chloride mean.

be locally influenced by culturally enriched tributaries and direct inputs from shore zone settlements.

The relative contributions of Maumee and Detroit River waters that mix in the study area can be estimated from data gathered on chemical concentrations in the Detroit and Maumee Rivers by governmental agencies over the period of study. Detroit River chloride data was obtained both by the Ontario Water Resources Commission (OWRC) and the Michigan Water Resources Commission (MWRC) along the same cross-river transect (Figure 1) but at different sampling times in 1971. The Michigan Water Resources Commission measured chloride throughout the study period. All of the profiles compared in Figure 10 agree closely and reveal the stable annual contributions of chloride to Lake Erie. Data were obtained by the Toledo Pollution Control Agency (TPCA) on chloride concentrations at one location on the west shore near the mouth of the Maumee River. This part of the river is influenced by lake seiches which can conceivably mix lake and river water at this location. These data, however, were assumed to be representative of lower Maumee River concentrations, and they agreed closely with chloride data obtained 34 kilometers upstream by the United States Geological Survey.

Assuming, then, that stations 2 and 6 are composed of Detroit and Maumee River water, and that stations 3, 4 and 5 contain Raisin River water in addition, a mass balance equation can be formulated and the relative contribution of each source determined. These calculations indicate that the Maumee River is particularly influential in the spring and less so in times of low water input during the fall (Table 4). In fact, fall contributions from the Maumee reflect

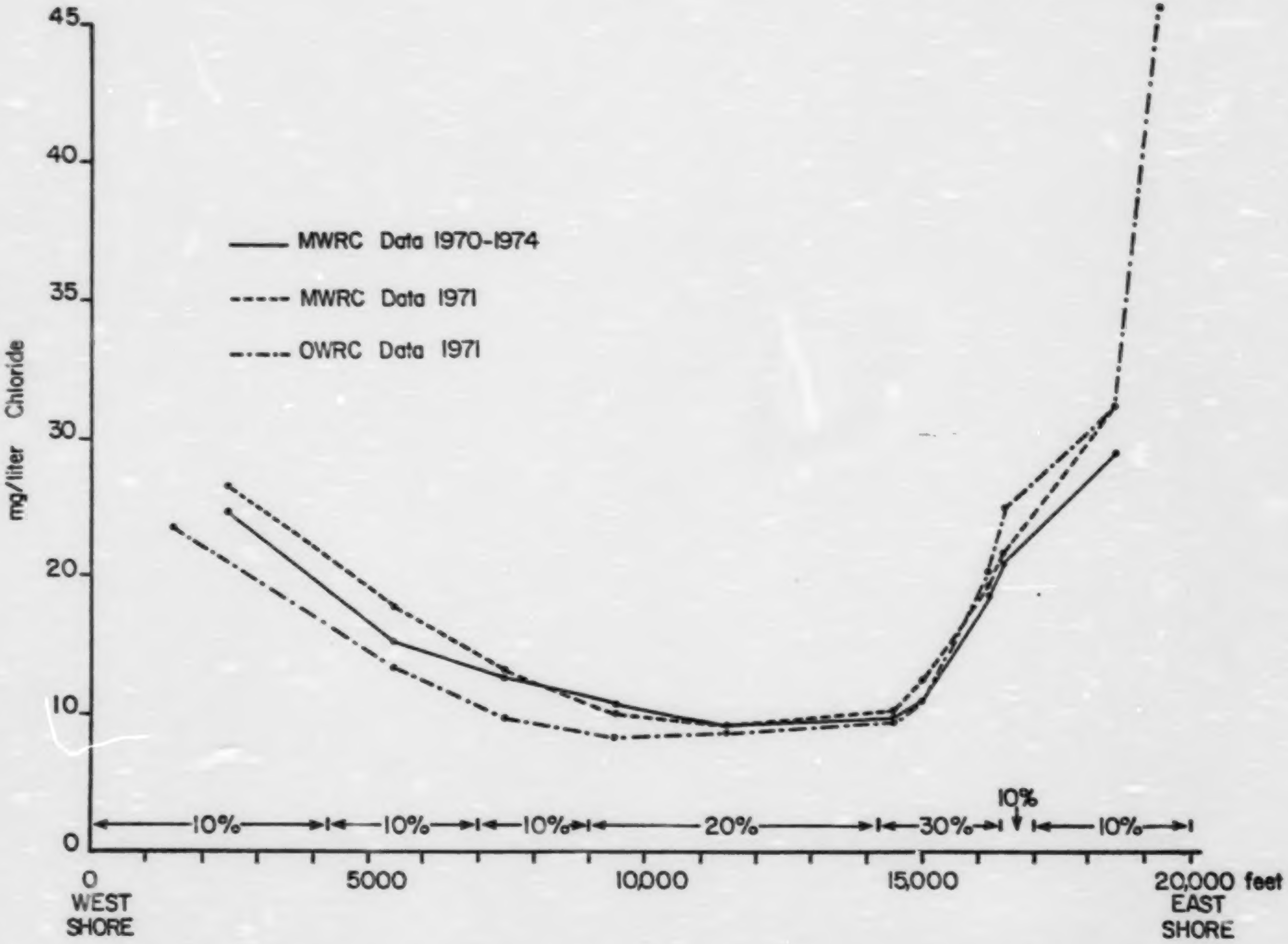


Figure 10. Chloride profiles for the Detroit River at Range 3.9, comparing data from the Michigan and Ontario Water Resources Commissions. Percentage figures represent the proportion of cross-sectional flow.

Table 4. Mean relative composition of lake stations based on chloride concentrations.

| | Lake Station | | | | |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 |
| Spring | | | | | |
| Detroit River | 0.857 | 0.799 | 0.741 | 0.805 | 0.821 |
| Maumee River | 0.143 | 0.140 | 0.136 | 0.155 | 0.179 |
| Raisin River | -- | 0.061 | 0.123 | 0.040 | -- |
| Summer | | | | | |
| Detroit River | 0.886 | 0.851 | 0.801 | 0.824 | 0.881 |
| Maumee River | 0.114 | 0.110 | 0.108 | 0.111 | 0.119 |
| Raisin River | -- | 0.039 | 0.091 | 0.065 | -- |
| Fall | | | | | |
| Detroit River | 0.929 | 0.857 | 0.845 | 0.907 | 0.951 |
| Maumee River | 0.071 | 0.102 | 0.104 | 0.057 | 0.049 |
| Raisin River | -- | 0.041 | 0.051 | 0.036 | -- |

an exceptional spate during the fall of 1972. Without that exceptionally high runoff, the Maumee River would not have had more than trace effects. At certain times of very high discharge, which might exceed the mean spring seasonal discharge by five or ten times, almost all of the water in the study area could have come from the Maumee River.

The proportion of Maumee River water remains fairly constant as the water masses proceed northward through the study area. Apparently Detroit and Maumee River water mix to the proportions found in the study area near the mouth of the Maumee River, and those proportions tend to be retained until after the water passes Stony Point. There it could be diluted to concentrations approaching the mean Detroit River concentrations, as indicated by Monroe city water. Water from the Raisin River mixes into this northward moving vacillating mass. Only at station 4 is the impact of the Raisin River as important as the impact of the Maumee River along this sampling transect. But, by far, the major source of water in the study area is the Detroit River, particularly during the late summer and fall. This also has been indicated by synoptic surveys conducted over a few days by Hartley, Herdendorf, and Keller (1966). These observations also support those of other workers who have suggested that a clockwise gyre usually dominates the circulation in the southwestern corner of western Lake Erie.

## Nitrogen

Nitrogen potentially could enter the gyre of southwestern Lake Erie from the Detroit, Maumee and Raisin Rivers as well as from the atmosphere. It may be lost to deep sediments or to the atmosphere as water passes through the western basin. This study generally indicates that the most important source of nitrogen to the study area is the watershed. Nitrogen fixation in the lake did not appear to be an important source. The nitrogen concentrations usually fluctuated widely in the study area (Figure 11) with the complexity of the changing tributary discharges and vacillating, wind-driven lake currents. But there were discernible seasonal trends. The nitrate nitrogen concentration (Figure 12), in particular, was high in spring and low in late summer and early fall. The ammonia nitrogen (Figure 13) was seasonally less variable than either nitrate nitrogen or organic nitrogen (Figure 14); the latter tended to increase through the growing season and peak during late summer and early fall. The concentrations of nitrogen measured in the Raisin River also exhibited the same seasonal trends (Table 5). These trends have been widely recognized by others (Vollenweider, 1968; Feth, 1966; and Hutchinson, 1957).

Assuming that the net movement of water through the study area is northward and, therefore, that Raisin River water mixes with water moving northward from station 6, the relative proportion of Raisin River water can be calculated from the chloride concentration of the sources for stations 4 and 5. The percentage compositions shown in Table 6 were calculated from chloride concentrations by assuming that Raisin River water and station 6 water combine to form station 5 water, and that station 5 and Raisin River water combine to produce station 4 water. As shown in Table 6, measured total nitrogen was usually less than had been predicted by this mixing scheme. The difference was most consistently due to nitrate nitrogen

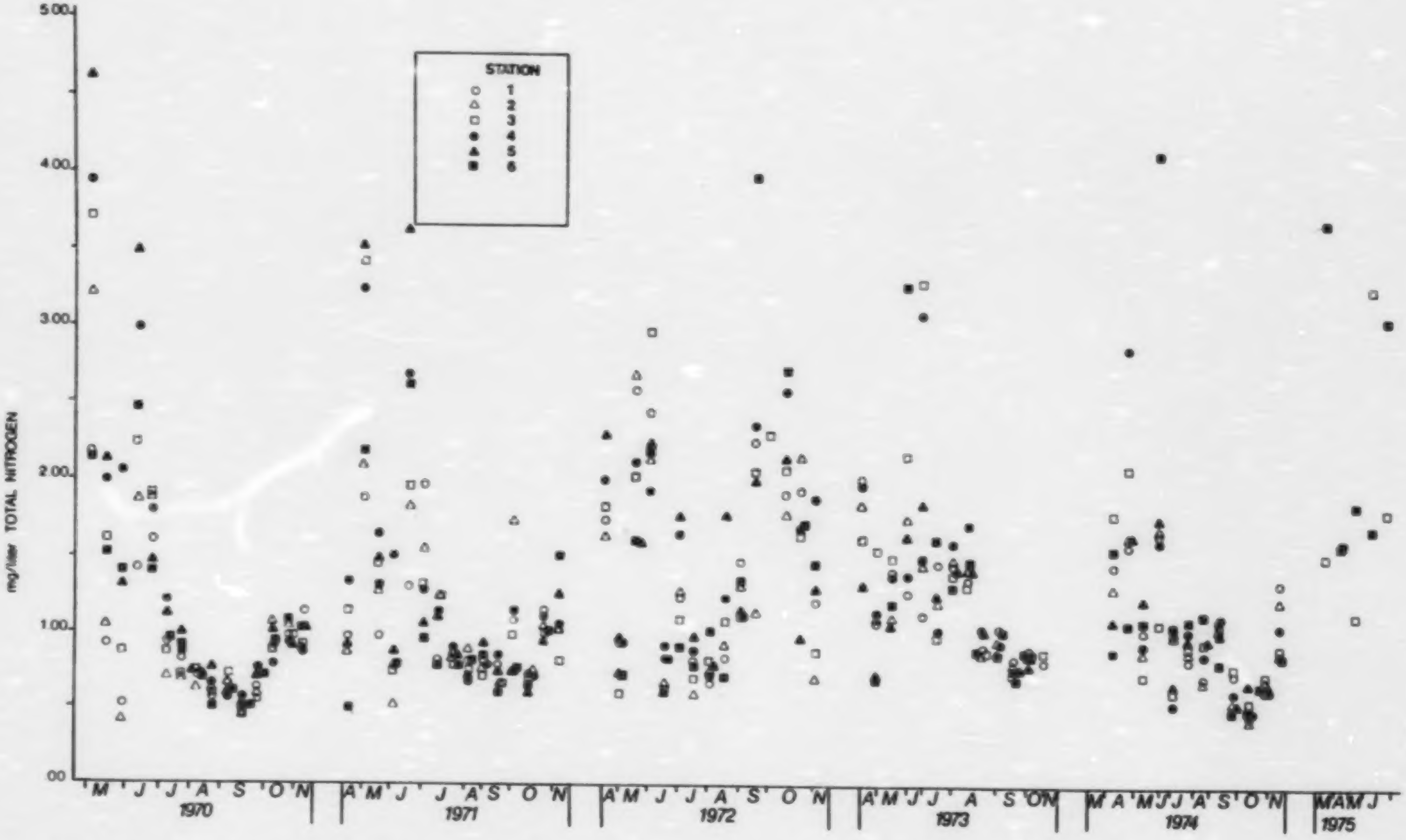


Figure 11. Total nitrogen concentrations at lake stations 1 through 6, 1970 through 1975.

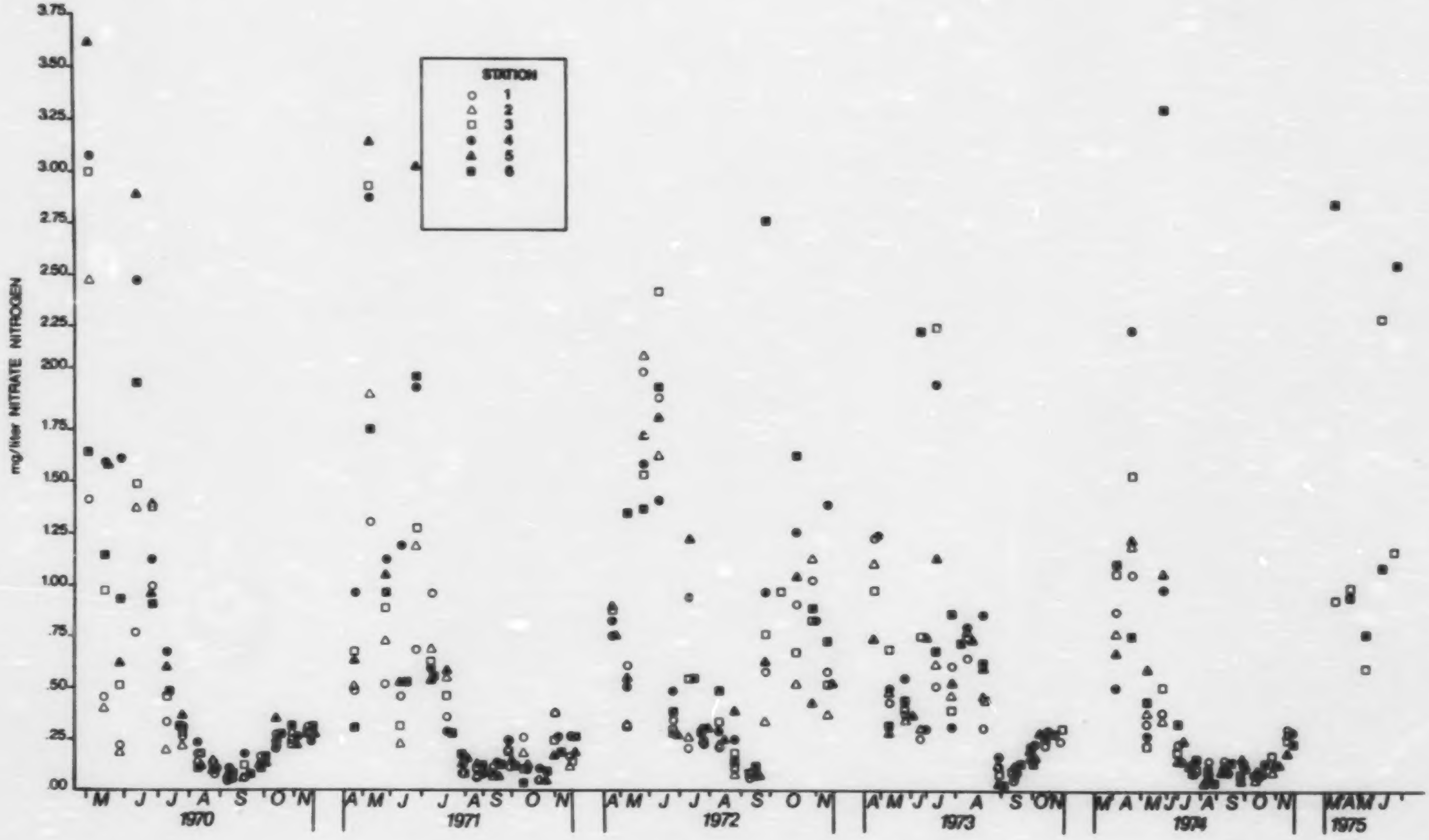


Figure 12. Nitrate nitrogen concentrations at lake stations 1 through 6, 1970 through 1975.

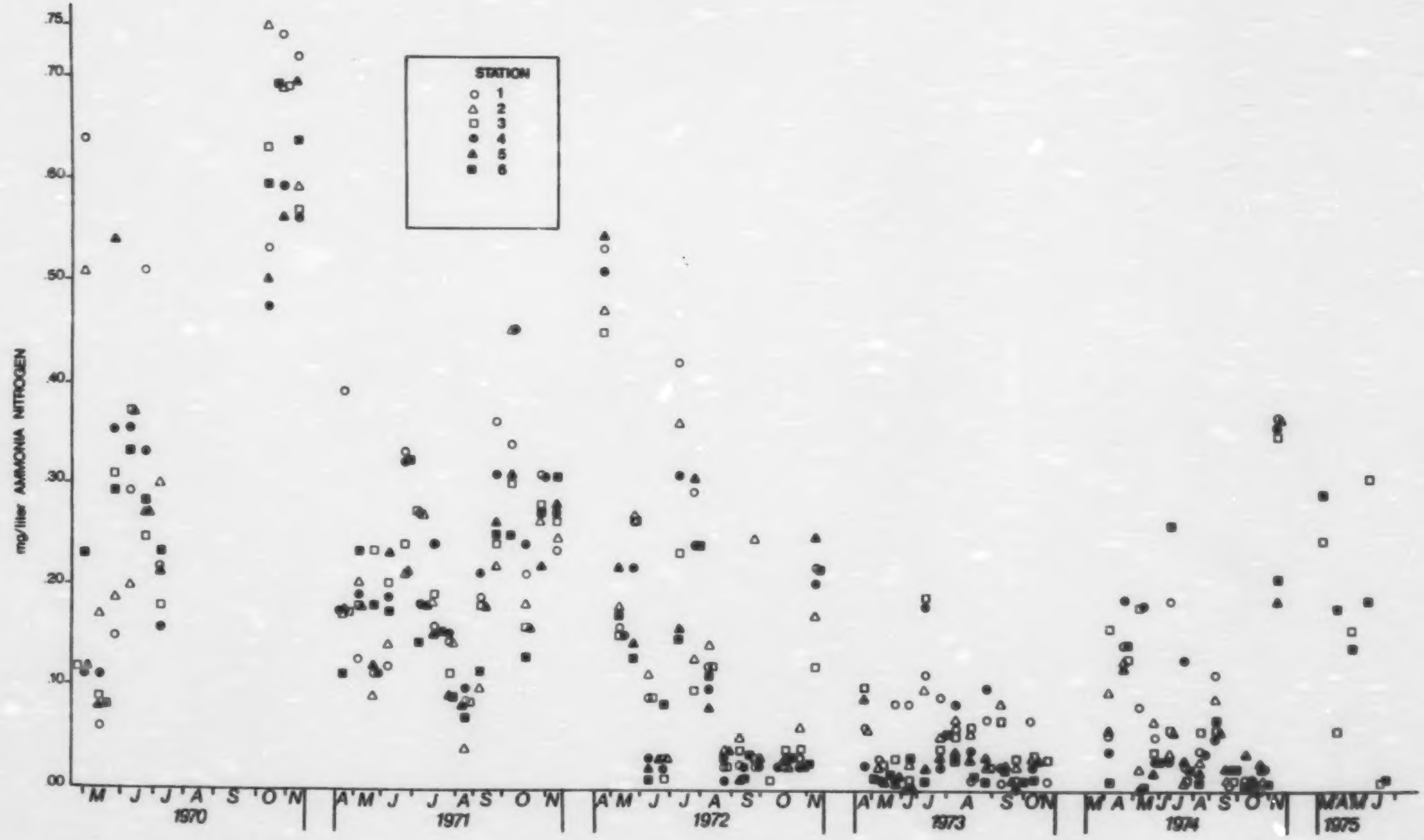


Figure 13. Ammonia nitrogen concentrations at lake stations 1 through 6, 1970 through 1975.

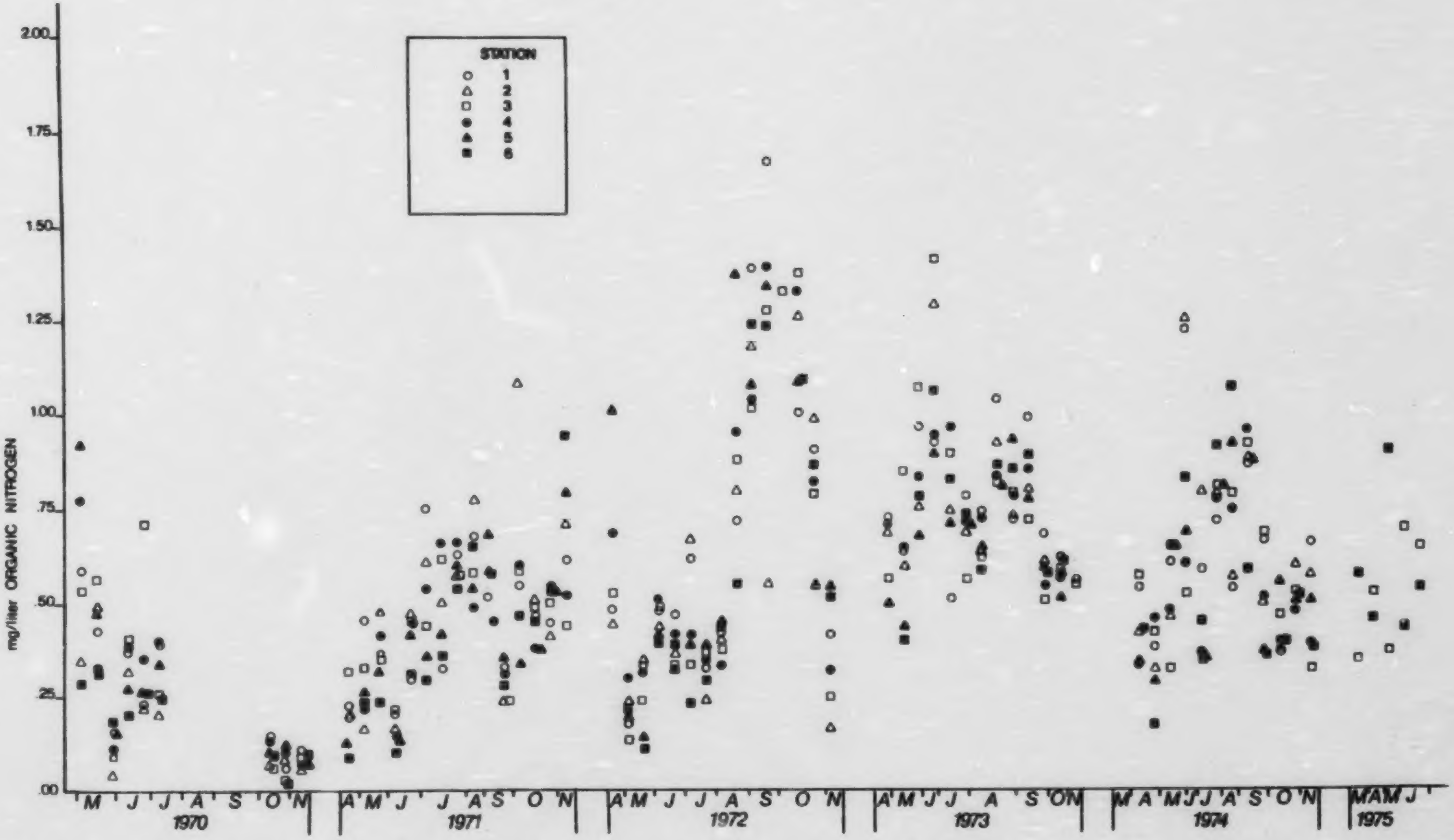


Figure 14. Organic nitrogen concentrations at lake stations 1 through 6, 1970 through 1975.

Table 5. Seasonal concentrations of nitrogen species in the Raisin River.

| | 1970 | 1971 | 1972 | 1973 | 1974 | Seasonal Mean |
|---|---|---|---|---|---|---|
| Total Nitrogen | | | | | | |
| Spring | 4.06 | 3.27 | 6.76 | 4.31 | 4.22 | 4.52 |
| Summer | 1.77 | 1.43 | 3.09 | 2.95 | 2.64 | 2.38 |
| Fall | 1.49 | 2.56 | 8.33 | 2.70 | 3.20 | 3.66 |
| Nitrate Nitrogen | | | | | | |
| Spring | 2.69 | 1.90 | 4.75 | 2.68 | 3.02 | 3.01 |
| Summer | 0.51 | 0.26 | 1.06 | 0.97 | 0.27 | 0.61 |
| Fall | 0.29 | 0.28 | 6.22 | 0.62 | 0.46 | 1.57 |
| Ammonia Nitrogen | | | | | | |
| Spring | 0.36 | 0.48 | 1.03 | 0.31 | 0.09 | 0.45 |
| Summer | 0.29 | 0.47 | 0.81 | 0.43 | 0.70 | 0.54 |
| Fall | 1.15 | 0.71 | 0.46 | 0.46 | 1.21 | 0.80 |
| Organic Nitrogen | | | | | | |
| Spring | 0.94 | 1.14 | 0.98 | 1.32 | 1.11 | 1.10 |
| Summer | 1.14 | 0.69 | 1.30 | 1.55 | 1.67 | 1.27 |
| Fall | 0.24 | 1.10 | 1.66 | 1.62 | 1.53 | 1.23 |

Table 6. Calculated and measured nitrogen parameters at lake stations 5 and 4 assuming that northward moving lake water mixes with Raisin River water.

| | Source | | Total Nitrogen | | Organic Nitrogen | |
|---|---|---|---|---|---|---|
| | Percent Station 6 | Percent Raisin River | Predicted mg/l | Measured mg/l | Predicted mg/l | Measured mg/l |
| Station 5 composition | | | | | | |
| Spring | 98.4 | 1.6 | 1.83 | 1.70 | 0.46 | 0.49 |
| Summer | 93.5 | 6.5 | 1.11 | 1.08 | 0.63 | 0.64 |
| Fall | 95.0 | 5.0 | 1.35 | 0.99 | 0.57 | 0.52 |
| | | | Nitrate Nitrogen | | Ammonia Nitrogen | |
| | | | Predicted mg/l | Measured mg/l | Predicted mg/l | Measured mg/l |
| Spring | | | 1.27 | 1.09 | 0.11 | 0.14 |
| Summer | | | 0.35 | 0.33 | 0.15 | 0.10 |
| Fall | | | 0.58 | 0.29 | 0.23 | 0.20 |

Table 6. (con't.)

| | Source | | Total Nitrogen | | Organic Nitrogen | |
|---|---|---|---|---|---|---|
| | Percent Station 6 | Percent Raisin River | Predicted mg/l | Measured mg/l | Predicted mg/l | Measured mg/l |
| Station 4 composition | | | | | | |
| Spring | 91.9 | 8.1 | 1.95 | 1.80 | 0.47 | 0.52 |
| Summer | 97.3 | 2.7 | 1.12 | 1.04 | 0.66 | 0.62 |
| Fall | 97.9 | 2.1 | 1.05 | 1.12 | 0.54 | 0.54 |
| | | | Nitrate Nitrogen | | Ammonia Nitrogen | |
| | | | Predicted mg/l | Measured mg/l | Predicted mg/l | Measured mg/l |
| Spring | | | 1.27 | 1.15 | 0.17 | 0.14 |
| Summer | | | 0.34 | 0.32 | 0.11 | 0.11 |
| Fall | | | 0.32 | 0.41 | 0.21 | 0.19 |

differences with little, if any, compensation from other forms of nitrogen. The Raisin River, therefore, has slightly less of an impact on total nitrogen concentration at the lake stations than simple dilution of river water by lake water would indicate.

There was very little indication that mean annual nitrate nitrogen (Table 7) changed in concentration as river and lake water mixed and passed through the cooling system of the Monroe Power Plant. There may have been a slight loss of ammonia nitrogen in spring (Table 8), but little change in organic nitrogen (Table 9) during passage. But overall, there was little change in total nitrogen (Table 10).

The nitrogen data obtained randomly from the study area in 1975 were plotted against the relative chloride concentrations (Figure 15). Concentrations of nitrate nitrogen were closely related to the chloride concentrations, probably reflecting coincidental shore zone inputs. The concentrations of organic nitrogen varied independently of the chloride concentrations, and concentrations of ammonia nitrogen were not as clearly related to chloride concentrations as were the concentrations of nitrate nitrogen. Most of the nitrogen that enters the lake from the tributaries comes in the form of nitrate nitrogen. Both ammonia and organic nitrogen are readily formed by biological processes in the lake proper from some portion of the nitrate nitrogen that enters the lake. Therefore, neither ammonia or organic nitrogen are as likely to be directly associated with shore zone inputs that have relatively high chloride concentrations.

Table 7. Annual nitrate nitrogen concentrations in the discharge canal.

| | Lake Station | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 17 | 9 | 18 | 12 | 8 | 14 | 15 | 16 |
| 1973 | 2.00 | 3.21 | 2.91 | 2.90 | 3.22 | 2.94 | 2.23 | 1.41 |
| 1974 | 0.93 | 1.72 | 1.25 | 1.37 | 1.33 | 1.37 | 1.02 | 0.73 |
| 1975 | 1.07 | 2.10 | 1.44 | 1.83 | 1.78 | 1.86 | 1.49 | 1.40 |
| Grand Mean | 1.33 | 2.34 | 1.87 | 2.03 | 2.11 | 2.06 | 1.58 | 1.18 |

Table 8. Annual ammonia nitrogen concentrations in the discharge canal.

| | Lake Station | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 17 | 9 | 18 | 12 | 8 | 14 | 15 | 16 |
| 1973 | 0.20 | 0.37 | 0.27 | 0.37 | 0.38 | 0.33 | 0.25 | 0.16 |
| 1974 | 0.07 | 0.29 | 0.10 | 0.19 | 0.21 | 0.21 | 0.11 | 0.06 |
| 1975 | 0.14 | 0.38 | 0.19 | 0.19 | 0.19 | 0.22 | 0.15 | 0.10 |
| Grand Mean | 0.14 | 0.35 | 0.19 | 0.25 | 0.26 | 0.25 | 0.17 | 0.11 |

Table 9. Annual organic nitrogen concentrations in the discharge canal.

| | Lake Station | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 17 | 9 | 18 | 12 | 8 | 14 | 15 | 16 |
| 1973 | 1.00 | 1.02 | 1.00 | 1.12 | 1.05 | 1.13 | 0.97 | 0.75 |
| 1974 | 0.53 | 1.02 | 0.64 | 0.74 | 0.58 | 0.56 | 0.58 | 0.45 |
| 1975 | 0.58 | 1.16 | 0.73 | 0.82 | 0.85 | 0.89 | 0.87 | 0.86 |
| Grand Mean | 0.70 | 1.07 | 0.79 | 0.89 | 0.83 | 0.86 | 0.81 | 0.69 |

Table 10. Annual total nitrogen concentrations in the discharge canal.

|  | Lake Station |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
| Year | 17 | 9 | 18 | 12 | 8 | 14 | 15 | 16 |
| 1973 | 3.21 | 4.60 | 4.18 | 4.45 | 4.39 | 4.46 | 3.55 | 2.31 |
| 1974 | 1.66 | 3.24 | 2.12 | 2.43 | 2.37 | 2.35 | 1.95 | 1.46 |
| 1975 | 1.78 | 3.65 | 2.37 | 2.84 | 2.83 | 2.96 | 2.50 | 2.36 |
| Grand Mean | 2.22 | 3.83 | 2.89 | 3.24 | 3.20 | 3.26 | 2.67 | 2.04 |

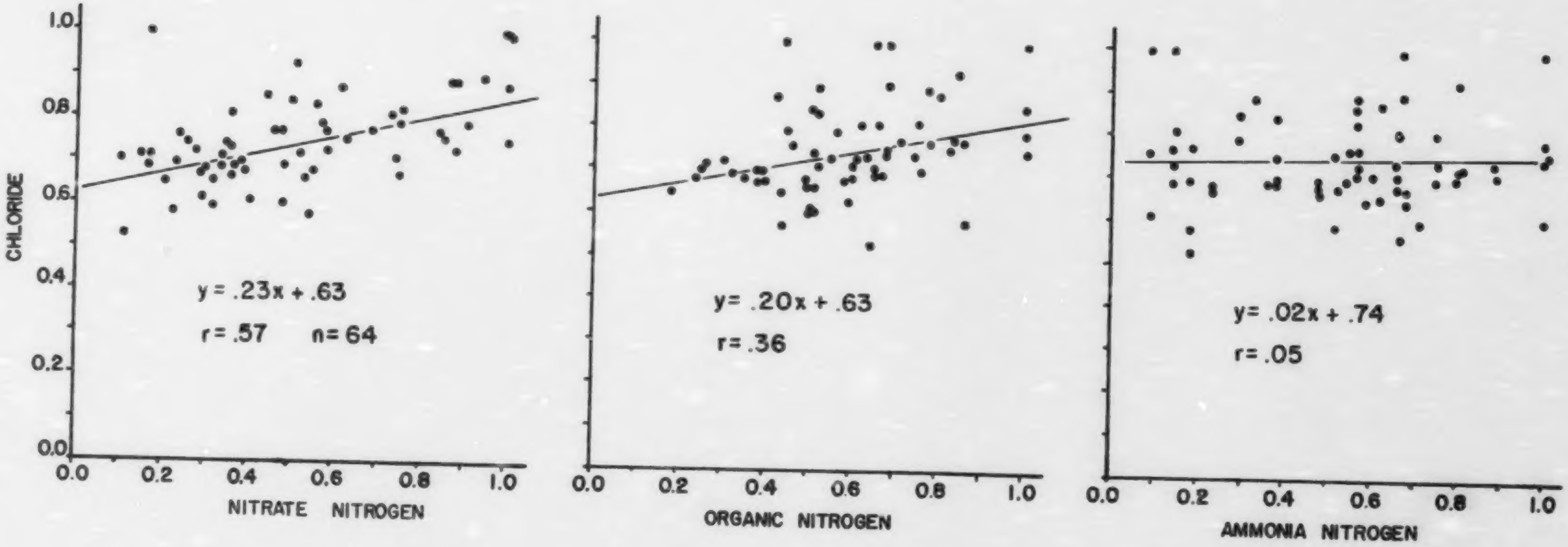


Figure 15. Plots of relative nitrate, organic, and ammonia nitrogen concentration vs. relative chloride concentration for the Spring, 1975, random samples.

Some data were collected on nitrogen concentrations for the Detroit and Maumee Rivers in conjunction with chloride measurements by the Michigan Water Resources Commission and the Toledo Pollution Control Agency. Only estimates of nitrate and ammonia nitrogen are available, however (Table 11). The predicted concentrations of inorganic nitrogen in the study area were not manifested as predicted by the mixing of different source waters alone (Table 4). Inorganic nitrogen (Table 12) was always less concentrated than predicted; 25 to 50 percent less in spring and fall, and 65 to 75 percent less in summer. The one exception was station 6 in the fall which showed only a six percent discrepancy. There also appeared to be a further decline as the water masses moved northward through the study area even though this decline was not predicted by any mixing phenomena. Both nitrate (Table 13) and ammonia nitrogen (Table 14) were less concentrated than predicted at station 6, but only nitrate nitrogen continued to decline in concentration as the water progressed northward through the study area. The ammonia concentrations may have increased slightly in partial compensation. Seasonal concentrations of organic nitrogen (Table A13) varied through the study area but with no indication of any trend up or down.

Substantial quantities of nitrogen seem to be lost from the water column mostly before it enters the study area during all seasons. Some nitrogen may be lost directly to the atmosphere as ammonia, although the usual pH encountered in western Lake Erie (less than 9.0) would seem to be too low to foster this loss. Organic nitrogen may settle to the bottom where denitrification

Table 11. Seasonal nitrate and ammonia nitrogen concentrations in the Maumee and Detroit Rivers.

| | 1970 | 1972 | 1973 | 1974 | Mean |
|---|---|---|---|---|---|
| Nitrate nitrogen concentrations | | | | | |
| Spring Detroit River | 0.37 | 0.35 | 0.28 | 0.36 | 0.34 |
| Spring Maumee River | 3.25 | 9.15 | 4.27 | 1.28 | 4.49 |
| Summer Detroit River | 0.37 | 0.29 | 0.21 | 0.22 | 0.27 |
| Summer Maumee River | 4.05 | 8.05 | 3.10 | 2.60 | 4.45 |
| Fall Detroit River | 0.13 | 0.19 | 0.25 | 0.22 | 0.20 |
| Fall Maumee River | 1.60 | 4.23 | 2.07 | 2.75 | 2.66 |
| Ammonia nitrogen concentrations | | | | | |
| Spring Detroit River | 0.50 | 0.52 | 0.38 | 0.48 | 0.47 |
| Spring Maumee River | 1.80 | 2.45 | 1.23 | 2.15 | 1.90 |
| Summer Detroit River | 0.46 | 0.46 | 0.37 | 0.35 | 0.41 |
| Summer Maumee River | 2.60 | 1.20 | 1.20 | 1.75 | 1.69 |
| Fall Detroit River | 0.29 | 0.31 | 0.40 | 0.35 | 0.33 |
| Fall Maumee River | 3.85 | 0.70 | 3.23 | 2.10 | 2.47 |

Table 12. Inorganic nitrogen concentrations as measured in the lake and as predicted from chloride concentrations.

| Season | Lake Station | | | | | |
|---|---|---|---|---|---|---|
| | 2 | | 3 | | 4 | |
| | Predicted | Measured | Predicted | Measured | Predicted | Measured |
| Spring | 1.60 | 0.98 | 1.77 | 1.17 | 1.93 | 1.29 |
| Summer | 1.31 | 0.35 | 1.31 | 0.34 | 1.32 | 0.43 |
| Fall | 0.86 | 0.50 | 1.09 | 0.54 | 1.12 | 0.60 |
| | 5 | | 6 | | | |
| Spring | 1.79 | 1.23 | 1.80 | 1.34 | | |
| Summer | 1.32 | 0.43 | 1.33 | 0.44 | | |
| Fall | 0.87 | 0.49 | 0.76 | 0.71 | | |

Table 13. Nitrate nitrogen concentrations as measured in the lake and as predicted from chloride concentrations.

| Season | Lake Station | | | | | |
|---|---|---|---|---|---|---|
| | 2 | | 3 | | 4 | |
| | Predicted | Measured | Predicted | Measured | Predicted | Measured |
| Spring | 0.93 | 0.83 | 1.10 | 1.02 | 1.27 | 1.15 |
| Summer | 0.75 | 0.22 | 0.75 | 0.25 | 0.76 | 0.32 |
| Fall | 0.37 | 0.27 | 0.52 | 0.33 | 0.54 | 0.41 |
| | 5 | | 6 | | | |
| Spring | 1.10 | 1.09 | 1.08 | 1.24 | | |
| Summer | 0.76 | 0.33 | 0.77 | 0.32 | | |
| Fall | 0.40 | 0.29 | 0.32 | 0.51 | | |

Table 14. Ammonia nitrogen concentrations as measured in the lake and as predicted from chloride concentrations.

| Season | Lake Station |  |  |  |  |  |
|---|---|---|---|---|---|---|
|  | 2 |  | 3 |  | 4 |  |
|  | Predicted | Measured | Predicted | Measured | Predicted | Measured |
| Spring | 0.67 | 0.15 | 0.67 | 0.15 | 0.66 | 0.14 |
| Summer | 0.56 | 0.13 | 0.56 | 0.09 | 0.56 | 0.11 |
| Fall | 0.49 | 0.23 | 0.57 | 0.21 | 0.58 | 0.19 |
|  | 5 |  | 6 |  |  |  |
| Spring | 0.69 | 0.14 | 0.72 | 0.10 |  |  |
| Summer | 0.56 | 0.10 | 0.56 | 0.12 |  |  |
| Fall | 0.47 | 0.20 | 0.44 | 0.20 |  |  |

could take place. Although atmospheric nitrogen fixation probably takes place in western Lake Erie at least for short periods of time (Mague and Burris, 1972; Howard _et al._, 1969), these data indicate that it is not likely to be a primary source of nitrogen in the study area because seasonal concentrations of inorganic nitrogen tend to be relatively high even during the summer.

Because of high concentrations, the Maumee and Raisin Rivers contribute inordinately higher masses of nitrogen to southwestern Lake Erie than indicated by their discharge. Therefore, nitrogen fixation may be relatively uncommon in this part of the western basin.

The Monroe Power Plant seems to have little effect on the dynamics of nitrogen other than to enhance the mixing of Raisin River water with waters derived almost entirely from the Detroit and Maumee Rivers. There appears to be a slight decrease in nitrogen concentration as water passes through the cooling system and into the lake. However, such decreases also seem to occur naturally on a much larger scale as water moves northward through the study area.

# CONCLUSIONS

From calculations based on the chloride concentrations in major influents, water in the study area was shown to be composed of Detroit, Maumee, and Raisin River waters. The relative proportions are a function of tributary discharge and wind driven currents. The Detroit River has a relatively high quality and uniform discharge that consists of water from the upper Great Lakes and wastewaters from the Detroit and Windsor municipalities. The Maumee and Raisin Rivers, on the other hand, receive municipal effluent in addition to runoff from an intensely farmed area. The difference in source waters coupled with the seasonal discharge characteristics of the Maumee and Raisin makes their impact on the study area highly variable over the ice-free seasons.

The chloride concentrations show that the tributary input remains in the near shore area, because chloride concentrations remain higher than that of the Detroit River. On a short term basis, the shore region can be flushed with low chloride lake water when the proper conditions are achieved. However, on a seasonal basis, the near shore waters seem to consist of tributary input other than the Detroit River. This water probably moves in either direction along the shore in response to wind, river input, and seiche activity.

Most of the nitrogen is contributed to the study area by the Maumee and Raisin Rivers as well as other small tributaries that drain land in the area. The great majority of this nitrogen is input as nitrate during periods of high discharge in winter and spring and occasionally in fall. This is a considerable proportion of the total nitrogen input to Lake Erie and its origin in the watershed is of considerable importance to those wishing to control nutrient inputs.

Based on chloride behavior, which is considered conservative, nitrogen in the study area shows a consistent net decrease from the values calculated from river inputs. Insufficient data are available to evaluate the mechanism of these losses; however, they are probably due to some combination of sedimentation and denitrification.

The main impact of the Monroe Power Plant, as traced by chloride ion, seems to be the movement of Raisin River waters to a new input site on Lake Erie and the dilution of that water by lake water prior to discharge to the lake. Discharge canal studies show a rapid mixing of discharge water with lake water, such that chloride concentrations are usually diluted to ambient lake values within five kilometers.

Some nitrogen may be lost on transit through the discharge canal, possibly controlled by the same factors that operate in the lake proper. The elevated temperature in the canal would also tend to accelerate any biological processes occurring therein.

This long term investigation into the seasonal impact of major tributaries in the study area, provides important background data needed to understand the biological processes in the ecosystem. Hopefully, it will contribute to the evaluation of present perturbations to the system, as well as provide meaningful methods and criteria for future planning, including power plant siting.

To be most helpful, continuing studies of this area should include year around monitoring of the major tributaries. With this information, Lake Erie's nitrogen and hydrodynamic systems could be modeled more accurately. Continuous monitoring would also provide better evaluation of both long and short term tributary effects.

Studies over the area might be expanded to investigate how mixing gradients are affected by the distance from shore. Hydrodynamics could also be more accurately ascertained by evaluating at least two independent conservative quantities. Chloride has been amply proven to be the best natural tracer so far, but perhaps sodium or sulfate could also be demonstrated to be useful as conservative tracers. With two conservative tracers the proportions of water consisting of three sources could be unambiguously defined. In addition, investigations nearer the shore might reveal some previously unrecognized source explaining the anomalously high chloride values at station 1.

## LITERATURE CITED

Andrews, T.F. 1948. Temporary changes of certain limnological conditions in western Lake Erie produced by a windstorm. Ecology 29(4): 501-505.

Anon. 1965. Standard Methods for the Examination of Water and Wastewater. 12th Edition. American Public Health Association, New York. 769 pp.

Anon. 1968. Lake Erie environmental summary, 1963-64. U.S. Dept. of the Interior, Great Lakes Region. Federal Water Pollution Control Administration. Cleveland, Ohio. 170 pp.

Anon. 1969. FWPCA methods for chemical analysis of water and wastes. U.S. Dept. of the Interior. Federal Water Pollution Control Administration. Cincinnati, Ohio. 280 pp.

Anon. 1971. Methods for chemical analysis of water and wastes. U.S. Environmental Protection Agency, Washington, D.C. 312 pp.

Beeton, A.M. 1961. Environmental changes in Lake Erie. Trans. Am. Fish. Soc. 90:153-159.

Beeton, A.M. 1971. Chemical characteristics of the Laurentian Great Lakes, In: Proceedings of the conference on changes in the chemistry of Lakes Erie and Ontario. Bull. Buffalo Soc. Nat. Sci. 25(2):1-21.

Carr, J.F., V.C. Applegate, and M. Keller. 1965. A recent occurrence of thermal stratification and low dissolved oxygen in western Lake Erie. Ohio J. Sci. 65(6):319-327.

Carr, J.F., and J.K. Hiltunen. 1965. Changes in the bottom fauna of western Lake Erie from 1930-1961. Limnol. Oceanogr., 10:551-569.

Chandler, D.C. and O.B. Weeks. 1945. Limnological studies of western Lake Erie. V. Relation of limnological and meteorological conditions to the production of phytoplankton in 1942. Ecol. Monogr. 15:435-457.

Cole, R.A. 1972. Physical and chemical limnology along the western shore of Lake Erie. Tech. Rep. 13. Institute of Water Res. Michigan State Univ., East Lansing, Mich. 120 pp.

Cole, R.A. 1973. An ecological evaluation of a thermal discharge: summary of early postoperational studies. Tech. Rep. 32.0. Institute of Water Res., Michigan State Univ., East Lansing, Mich. 43 pp.

Cole, R.A. and R. Freeman. 1972. An ecological evaluation of a thermal discharge. Part IV: Preoperational Studies, 1970-1971. Tech. Rep. 16. Institute of Water Res., Michigan State Univ., East Lansing, Mich. 98 pp.

Curl, H.C. 1957. A source of phosphorus for the western basin of Lake Erie. Limnol. Oceanogr. 2:315-320.

Davis, Charles C. 1964. Evidence for the eutrophication of Lake Erie from phytoplankton records. Limnol. Oceanogr. 9:275-283.

Eaton, U.S., G.E. Likens, and F.H. Bormann. 1969. Use of membrane filters in gravimetric analyses of particulate matter in natural waters. Water Resour. Res. 5(5):1151-1156.

Feth, J.H. 1966. Nitrogen compounds in natural water -- a review. Water Resour. Res. 2:41-58.

Harlow, G.L. 1966. Major sources of nutrients for algal growth in western Lake Erie. Univ. Michigan. Great Lakes Res. Div. Proc. 9th Conf. on Great Lakes Res. Pub. no. 15. p. 389-394.

Hartley, R.P. 1968. Bottom currents in Lake Erie. Univ. Michigan. Great Lakes Res. Div. Proc. 11th Conf. on Great Lakes Res. p. 398-405.

Hartley, R.P., C.E. Herdendorf, and M. Keller. 1966. Synoptic water sampling survey in the western basin of Lake Erie. Univ. Michigan Great Lakes Res. Div. Proc. 9th Conf. on Great Lakes Res. Pub. 15, p. 301-322.

Harwood, J.E. and A.L. Kuhn. 1970. A colorimetric method for ammonia in natural waters. Water Res. 4:805-811.

Hem, J.D. 1970. Study and interpretation of the chemical characteristics of natural water 2nd edition. Geological survey water supply paper 1473. U.S. Geological Survey. U.S. Government Printing Office. Washington, D.C. 363 pp.

Herdendorf, C.E. 1969. Water masses and their movements in western Lake Erie. Ohio Div. Geol. Survey Dept. No. 74. Columbus, Ohio. 7 pp.

Howe, L.H. and C.W. Holley. 1969. Comparisons of mercury (II) chloride and sulfuric acid as preservatives for nitrogen forms in water samples. Environ. Sci. and Technol. 3:478-481.

Hutchinson, G.E. 1957. A treatise on limnology. Vol. 1. Geography, Physics, and Chemistry. John Wiley, New York. 1015 pp.

Jenkins, D. and L.L. Medsker. 1964. A brucine method for the determination of nitrate in ocean, estuarine, and fresh waters. Anal. Chem. 36:610-612.

Kaufman, W.J. and G.T. Orlob. 1956. Measuring ground water movement with radioactive and chemical tracers. J. Am. Water Works Assoc. 48:559-572.

Ketchum, B.H. 1951. The exchanges of fresh and salt water tidal estuaries. J. Mar. Res. 10:18-38.

Ketchum, B.H. 1967. Phytoplankton nutrients in estuaries. In: G.H. Lauff (ed.) The Estuaries, Pub. No. 83, Amer. Assoc. Adv. Sci., 757 pp.

Kovacik, T.L. 1972. Information on the velocity and flow pattern of Detroit River water in western Lake Erie revealed by an accidental salt spill. Ohio J. Sci., 72(3):81-86.

Langlois, T.H. 1954. The western end of Lake Erie and its ecology. U.W. Edwards, Pub. Ann Arbor, Mich. 479 pp.

O'Leary, L.B. 1966. Synoptic vector method for measuring water mass movements in western Lake Erie. Univ. Michigan Great Lakes Res. Div. Proc. 9th Conf. on Great Lakes Res. Pub. 15:337-344.

Olsen, F.C.W. 1950. The currents of western Lake Erie. Ph.D. thesis, Ohio State Univ., Columbus, Ohio.

Public Health Service. 1965. Proceedings Vol. 2: Conference in the matter of pollution of navigable waters of the Detroit River and Lake Erie and their tributaries in the State of Michigan. Washington, D.C. 304 pp.

Shaffer, P.W. 1974. An ecological evaluation of the fate of radioisotopes from Fermi II nuclear power plant in western Lake Erie: trace elements and background gamma levels in water and sediments near the western shore of Lake Erie. M.S. thesis. Michigan State University, East Lansing, Mich. 125 pp.

Spain, J.D. and S.C. Andrews. 1970. Water mass identification in a small lake using conserved chemical constituents. Univ. Michigan Great Lakes Res. Div. Proc. 13th Conf. on Great Lakes Res. p. 733-743.

Steele, R.G.D. and J.H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Co., New York. 481 pp.

Verber, J.L. 1953. Surface water movement, western Lake Erie. Ohio J. Sci. 51(1):42-46.

Verber, J.L. 1955. Surface water movement in western Lake Erie. Int. Assoc. Theor. Appl. Limnol. Proc. 12:97-104.

Verduin, J. 1969. Man's influence on Lake Erie. Ohio J. Sci. 69:65-69.

Vollenweider, R.A. 1968. Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication. Organ. Econ. Coop. and Dev. Rep., Paris.

Walters, L.V. Jr., C.E. Herdendorf, L.J. Charlesworth, Jr., H.K. Anders, W.B. Jackson, E.J. Skoch, D.K. Webb, T.L. Kovacik, and C.S. Sikes. 1972. Mercury contamination and its relation to other physicochemical parameters in the western basin of Lake Erie. Univ. Michigan Great Lakes Res. Div. Proc. 15th Conf. on Great Lakes Res. p. 306-316.

Wright, S., L.H. Tiffany, and W.M. Tidd. 1955. Limnological survey of western Lake Erie. U.S. Fish. Wildl. Serv. Spec. Sci. Fish Rep. 139. Washington, D.C. 341 pp.

# APPENDICES

Table A1. Mean concentration of chloride in mg/l by station.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 5 | 1 | 3 | 2 | 4 | 9 | 7* | 8 |
| 1 May 70 | 19.1 | 19.8 | 21.1 | 21.4 | 21.9 | 23.3 | 29.3 | 33.2 | 33.5 |
| | 4 | 2 | 6 | 3 | 5 | 1 | 8 | 7* | 9 |
| 15 May 70† | 19.1 | 19.8 | 19.9 | 20.4 | 20.5 | 21.8 | 24.2 | 25.3 | 29.4 |
| | 2 | 1 | 3 | 6 | 5 | 4 | 8 | 9 | 7* |
| 27 May 70 | 16.5 | 17.8 | 17.9 | 18.8 | 19.7 | 22.4 | 27.5 | 28.4 | 29.8 |
| | 5 | 2 | 1 | 6 | 3 | 4 | 8 | 9 | 7* |
| 10 June 70 | 18.4 | 19.2 | 19.6 | 19.8 | 20.3 | 20.9 | 22.4 | 24.3 | 31.5 |
| | 5 | 4 | 6 | 2 | 1 | 3 | 9 | 8 | 7* |
| 23 June 70† | 20.3 | 20.4 | 20.8 | 21.1 | 21.9 | 22.2 | 31.6 | 32.1 | 36.8 |
| | 2 | 1 | 6 | 5 | 3 | 4 | 8 | 9 | 7* |
| 7 July 70† | 14.5 | 17.3 | 18.8 | 18.9 | 19.1 | 19.3 | 23.0 | 23.9 | 31.3 |
| | 6 | 2 | 1 | 5 | 3 | 4 | 7* | 8 | 9 |
| 21 July 70 | 17.3 | 19.0 | 19.5 | 20.1 | 20.1 | 20.4 | 30.1 | 30.7 | 32.5 |
| | 6 | 2 | 1 | 5 | 4 | 3 | 8 | 7* | 9 |
| 4 Aug 70 | 23.8 | 27.8 | 28.3 | 29.3 | 30.7 | 31.8 | 32.3 | 35.4 | 35.9 |
| | 3 | 2 | 5 | 4 | 7* | 1 | 8 | 9 | |
| 18 Aug 70 | 25.5 | 33.6 | 34.2 | 34.3 | 34.5 | 34.7 | 39.8 | 40.3 | |

Table A1 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 5 | 3 | 1 | 4 | 2 | 8 | 7* | 9 |
| 1 Sept 70 | 22.4 | 23.1 | 24.1 | 25.5 | 25.7 | 26.2 | 27.5 | 28.0 | 36.6 |
| | 6 | 4 | 3 | 1 | 5 | 2 | 7* | 8 | 9 |
| 15 Sept 70 | 21.9 | 23.2 | 23.9 | 24.7 | 24.7 | 25.0 | 26.2 | 30.0 | 32.0 |
| | 6 | 2 | 4 | 1 | 5 | 3 | 7* | 8 | 9 |
| 27 Sept 70 | 20.9 | 22.7 | 23.5 | 24.3 | 24.9 | 25.0 | 26.3 | 27.4 | 40.2 |
| | 2 | 6 | 5 | 1 | 3 | 7* | 4 | 8 | 9 |
| 10 Oct 70 | 17.6 | 18.0 | 18.7 | 18.7 | 19.4 | 20.1 | 20.3 | 36.6 | 39.0 |
| | 3 | 6 | 5 | 4 | 8 | 7* | 1 | 2 | 9 |
| 25 Oct 70 | 18.8 | 19.3 | 19.4 | 19.5 | 20.0 | 21.5 | 22.3 | 22.6 | 26.3 |
| | 6 | 3 | 2 | 8 | 1 | 4 | 7* | 5 | 9 |
| 7 Nov 70 | 15.2 | 20.8 | 21.9 | 22.5 | 23.4 | 24.1 | 24.3 | 29.3 | 30.3 |
| | 2 | 1 | 5 | 9 | 4 | 3 | 8 | 7* | |
| 22 Apr 72 | 32.7 | 35.0 | 38.2 | 40.3 | 44.0 | 44.0 | 46.2 | 61.3 | |
| | 3 | 2 | 4 | 5 | 6 | 1 | 9 | 8 | 7* |
| 11 May 72 | 14.7 | 16.3 | 24.8 | 25.1 | 26.1 | 26.3 | 41.8 | 42.2 | 50.0 |
| | 6 | 5 | 1 | 4 | 3 | 2 | 8 | 7* | 9 |
| 31 May 72 | 19.6 | 21.0 | 23.4 | 24.1 | 24.3 | 24.5 | 29.3 | 31.2 | 33.8 |
| | 2 | 6 | 5 | 1 | 3 | 4 | 8 | 7* | 9 |
| 13 June 72 | 19.3 | 19.8 | 19.8 | 20.0 | 20.3 | 20.4 | 24.9 | 25.8 | 45.5 |

Table A1 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 3 | 4 | 1 | 2 | 6 | 8 | 7* | 9 |
| 27 June 72 | 9.6 | 9.9 | 11.1 | 11.2 | 11.4 | 12.8 | 18.7 | 25.0 | 46.0 |
| | 6 | 1 | 2 | 3 | 5 | 4 | 8 | 9 | |
| 12 July 72 | 14.5 | 14.9 | 15.2 | 17.9 | 19.1 | 19.5 | 23.1 | 45.6 | |
| | 1 | 4 | 2 | 3 | 5 | 6 | 7* | 8 | 9 |
| 25 July 72 | 12.4 | 13.0 | 13.1 | 13.3 | 14.4 | 15.9 | 16.7 | 17.5 | 24.2 |
| | 5 | 1 | 2 | 4 | 3 | 6 | 7* | 8 | 9 |
| 16 Aug 72 | 14.4 | 14.9 | 15.0 | 15.0 | 16.4 | 17.4 | 20.5 | 20.9 | 40.3 |
| | 2 | 6 | 3 | 1 | 5 | 8 | 4 | 7* | 9 |
| 29 Aug 72 | 15.7 | 16.1 | 16.7 | 20.9 | 21.8 | 23.8 | 24.0 | 24.1 | 46.6 |
| | 2 | 4 | 5 | 1 | 3 | 6 | 8 | 7* | 9 |
| 12 Sept 72 | 17.4 | 17.4 | 18.0 | 18.3 | 18.7 | 19.2 | 24.0 | 24.5 | 41.8 |
| | 2 | 6 | 1 | 4 | 3 | 5 | 7* | 8 | 9 |
| 29 Sept 72 | 15.2 | 16.3 | 18.3 | 18.4 | 18.5 | 19.1 | 30.6 | 30.8 | 42.5 |
| | 3 | 8 | 9 | | | | | | |
| 6 Oct 72 | 17.2 | 30.8 | 43.0 | | | | | | |
| | 2 | 3 | 6 | 5 | 1 | 4 | 8 | 7* | 9 |
| 13 Oct 72 | 14.7 | 17.9 | 18.0 | 18.1 | 18.3 | 19.2 | 31.8 | 33.3 | 44.2 |
| | 5 | 3 | 4 | 6 | 1 | 2 | 8 | 7* | 9 |
| 27 Oct 72 | 12.3 | 16.3 | 16.9 | 17.2 | 18.2 | 21.8 | 35.0 | 37.2 | 43.1 |
| | 2 | 3 | 1 | 4 | 5 | 6 | 8 | 7* | 9 |
| 15 Nov 72 | 9.0 | 12.8 | 15.5 | 15.6 | 17.0 | 18.2 | 30.5 | 33.7 | 34.1 |

Table A1 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 7 Feb 73 | 1 | 3 | 8 | 9 | 7 | | | | |
| | 14.3 | 20.1 | 29.0 | 29.3 | 30.3 | | | | |
| 24 April 73 | 5 | 3 | 2 | 4 | 1 | 8 | 7 | 9 | |
| | 18.4 | 20.2 | 20.4 | 20.6 | 22.0 | 26.9 | 27.5 | 31.4 | |
| 11 May 73 | 4 | 5 | 1 | 2 | 3 | 6 | 8 | 7 | 9 |
| | 15.4 | 16.0 | 16.4 | 16.6 | 18.2 | 18.3 | 24.4 | 25.3 | 29.3 |
| 30 May 73 | 2 | 5 | 1 | 3 | 6 | 4 | 9 | 8 | 7 |
| | 14.3 | 14.9 | 15.8 | 16.6 | 17.0 | 17.9 | 28.1 | 29.4 | 29.8 |
| 20 June 73 | 1 | 2 | 5 | 4 | 6 | 3 | 8 | 7 | 9 |
| | 16.7 | 16.9 | 17.2 | 17.4 | 17.6 | 18.6 | 22.0 | 22.8 | 26.8 |
| 6 July 73 | 1 | 2 | 6 | 3 | 5 | 4 | 7 | 8 | 9 |
| | 14.3 | 15.1 | 15.9 | 16.3 | 17.0 | 17.5 | 20.3 | 20.4 | 33.7 |
| 17 July 73 | 4 | 3 | 2 | 5 | 1 | 6 | 8 | 7 | 9 |
| | 14.1 | 15.4 | 15.4 | 15.9 | 16.0 | 17.0 | 20.2 | 20.8 | 30.7 |
| 1 Aug 73 | 2 | 3 | 6 | 5 | 1 | 4 | 8 | 7 | 9 |
| | 15.8 | 16.4 | 16.6 | 16.8 | 17.1 | 17.6 | 26.0 | 27.2 | 39.2 |
| 15 Aug 73 | 2 | 5 | 4 | 3 | 1 | 6 | 8 | 7 | 9 |
| | 16.6 | 16.7 | 16.9 | 17.0 | 17.1 | 17.7 | 20.2 | 20.7 | 43.2 |
| 28 Aug 73 | 2 | 1 | 3 | 4 | 6 | 5 | 8 | 7 | 9 |
| | 15.2 | 15.3 | 16.0 | 16.1 | 16.5 | 17.1 | 18.8 | 20.0 | 34.2 |
| 10 Sept 73 | 2 | 3 | 5 | 1 | 4 | 6 | 7 | 8 | 9 |
| | 13.8 | 14.2 | 14.5 | 14.6 | 14.9 | 16.5 | 20.1 | 20.3 | 46.0 |
| 24 Sept 73 | 2 | 1 | 3 | 6 | 5 | 4 | 8 | 7 | 9 |
| | 11.5 | 11.8 | 12.3 | 13.9 | 13.9 | 14.4 | 15.2 | 15.6 | 32.5 |
| 8 Oct 73 | 1 | 4 | 5 | 6 | 2 | 3 | 7 | 8 | 9 |
| | 13.7 | 14.6 | 14.7 | 14.8 | 14.9 | 15.3 | 18.6 | 18.6 | 31.8 |

Table A1 (con't )

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 13 Nov 73 | 3 | 1 | 7 | 8 | 9 | | | | |
| | 15.3 | 17.6 | 25.2 | 25.3 | 28.4 | | | | |
| 14 Mar 74 | 9 | 8 | 7 | 5 | 6 | 4 | 2 | 3 | 1 |
| | 21.0 | 21.5 | 22.2 | 22.4 | 27.0 | 28.0 | 30.3 | 30.4 | 30.6 |
| 3 April 74 | 1 | 2 | 4 | 6 | 5 | 3 | 9 | 8 | 7 |
| | 16.8 | 16.9 | 18.5 | 19.2 | 19.3 | 20.3 | 29.7 | 31.5 | 33.8 |
| 17 April 74 | 3 | 1 | 4 | 5 | 2 | 6 | 8 | 7 | 9 |
| | 17.4 | 19.0 | 19.0 | 19.4 | 20.1 | 22.7 | 26.7 | 28.3 | 28.9 |
| 7 May 74 | 3 | 2 | 1 | 4 | 6 | 5 | 8 | 7 | 9 |
| | 12.8 | 14.7 | 16.1 | 18.4 | 19.0 | 20.5 | 25.8 | 26.3 | 36.0 |
| 22 May 74 | 4 | 2 | 5 | 1 | 3 | 8 | 6 | 9 | 7 |
| | 21.0 | 21.3 | 21.6 | 21.9 | 22.1 | 24.0 | 24.6 | 24.6 | 25.8 |
| 31 July 74 | 2 | 1 | 3 | 4 | 8 | 6 | 5 | 7 | 9 |
| | 15.4 | 16.7 | 17.6 | 19.5 | 19.7 | 19.8 | 20.1 | 21.0 | 42.8 |
| 13 Aug 74 | 2 | 1 | 3 | 8 | 5 | 7 | 6 | 4 | 9 |
| | 17.3 | 18.3 | 19.1 | 19.9 | 20.3 | 20.4 | 20.7 | 21.7 | 44.5 |
| 11 Sept 74 | 6 | 5 | 2 | 1 | 4 | 3 | 8 | 7 | 9 |
| | 14.4 | 16.4 | 17.2 | 17.6 | 17.6 | 17.9 | 21.8 | 22.3 | 39.2 |
| 27 Sept 74 | 5 | 6 | 4 | 2 | 3 | 1 | 7 | 8 | 9 |
| | 11.5 | 11.6 | 12.2 | 12.9 | 14.3 | 15.6 | 18.5 | 18.8 | 45.4 |
| 7 Oct 74 | 4 | 1 | 6 | 3 | 2 | 5 | 8 | 7 | 9 |
| | 11.7 | 11.8 | 12.8 | 12.8 | 12.9 | 13.2 | 14.1 | 14.6 | 23.2 |
| 24 Oct 74 | 5 | 6 | 1 | 3 | 2 | 4 | 7 | 8 | 9 |
| | 12.0 | 13.1 | 13.2 | 13.9 | 14.2 | 14.6 | 20.3 | 21.5 | 27.4 |
| 7 Nov 74 | 6 | 5 | 4 | 2 | 1 | 3 | 7 | 8 | 9 |
| | 11.4 | 17.8 | 22.4 | 25.3 | 26.7 | 27.1 | 27.3 | 27.4 | 40.5 |
| 18 Mar 75 | 3 | 6 | 8 | 9 | | | | | |
| | 21.5 | 25.2 | 32.0 | 32.1 | | | | | |

Table A1 (con't.)

| | | | | |
|---|---|---|---|---|
| 6 May 75 | 3 | 6 | 8 | 9 |
| | 15.4 | 22.2 | 28.3 | 28.5 |
| 4 June 75 | 6 | 3 | 8 | 9 |
| | 19.3 | 24.1 | 29.2 | 38.3 |
| 24 June 75 | 3 | 6 | 8 | 9 |
| | 17.7 | 18.0 | 20.8 | 33.8 |

Table A2. Mean concentration of total nitrogen in mg/l by station.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 1 | 2 | 9 | 3 | 8 | 4 | 7* | 5 |
| 1 May 70 | 2.18 | 2.20 | 3.24 | 3.64 | 3.74 | 3.75 | 3.97 | 4.13 | 4.66 |
| | 1 | 2 | 6 | 3 | 4 | 5 | 7* | 8 | 9 |
| 15 May 70 | 0.93 | 1.07 | 1.53 | 1.63 | 2.01 | 2.14 | 2.21 | 2.27 | 2.44 |
| | 2 | 1 | 3 | 5 | 6 | 4 | 7* | 8 | 9 |
| 27 May 70 | 0.43 | 0.54 | 0.89 | 1.33 | 1.42 | 2.07 | 2.90 | 3.47 | 5.93 |
| | 1 | 2 | 9 | 7* | 3 | 8 | 6 | 4 | 5 |
| 10 June 70† | 1.43 | 1.88 | 2.08 | 2.10 | 2.25 | 2.34 | 2.48 | 3.00 | 3.53 |
| | 6 | 5 | 1 | 4 | 2 | 3 | 8 | 7* | 9 |
| 23 June 70 | 1.42 | 1.48 | 1.62 | 1.81 | 1.90 | 1.92 | 3.28 | 3.76 | 6.08 |
| | 2 | 3 | 1 | 6 | 5 | 4 | 8 | 9 | 7* |
| 7 July 70† | 0.71 | 0.88 | 0.94 | 0.96 | 1.12 | 1.22 | 1.78 | 1.89 | 1.98 |
| | 2 | 3 | 1 | 4 | 6 | 5 | 8 | 7* | 9 |
| 21 July 70 | 0.70 | 0.71 | 0.82 | 0.87 | 0.92 | 1.00 | 1.46 | 1.98 | 2.15 |
| | 2 | 1 | 6 | 4 | 3 | 5 | 7* | 8 | 9 |
| 4 Aug 70 | 0.65 | 0.71 | 0.72 | 0.73 | 0.75 | 0.76 | 1.76 | 1.83 | 2.08 |
| | 6 | 1 | 3 | 2 | 4 | 5 | 8 | 9 | 7* |
| 18 Aug 70 | 0.53 | 0.57 | 0.58 | 0.62 | 0.67 | 0.77 | 1.45 | 1.52 | 1.95 |

Table A2 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 2 | 1 | 3 | 9 | 8 | 7* |
| 1 Sept 70 | 0.58 | 0.60 | 0.63 | 0.67 | 0.67 | 0.72 | 1.27 | 1.39 | 1.56 |
| | 3 | 2 | 1 | 6 | 5 | 4 | 9 | 8 | 7* |
| 15 Sept 70 | 0.46 | 0.46 | 0.51 | 0.51 | 0.53 | 0.58 | 1.04 | 1.21 | 1.35 |
| | 3 | 2 | 1 | 5 | 6 | 4 | 9 | 7* | 8 |
| 27 Sept 70 | 0.56 | 0.60 | 0.65 | 0.74 | 0.74 | 0.77 | 1.33 | 1.43 | 1.51 |
| | 4 | 3 | 1 | 6 | 7* | 5 | 2 | 8 | 9 |
| 10 Oct 70† | 0.80 | 0.89 | 0.92 | 0.93 | 1.00 | 1.02 | 1.09 | 1.46 | 1.47 |
| | 5 | 4 | 3 | 1 | 2 | 6 | 7* | 8 | 9 |
| 25 Oct 70 | 0.93 | 0.93 | 0.99 | 0.99 | 1.06 | 1.07 | 1.61 | 1.61 | 1.69 |
| | 4 | 2 | 3 | 5 | 6 | 7* | 1 | 8 | 9 |
| 7 Nov 70 | 0.88 | 0.91 | 0.92 | 1.04 | 1.04 | 1.10 | 1.15 | 1.25 | 1.90 |
| | 2 | 8 | 7* | | | | | | |
| 23 Jan 71 | 0.60 | 1.37 | 1.79 | | | | | | |
| | 1 | 7* | | | | | | | |
| 18 Feb 71 | 0.52 | 1.95 | | | | | | | |
| | 6 | 2 | 5 | 1 | 3 | 4 | 9 | 8 | 7* |
| 16 Apr 71 | 0.50 | 0.87 | 0.92 | 0.98 | 1.15 | 1.34 | 2.68 | 2.84 | 3.28 |
| | 1 | 2 | 6 | 4 | 3 | 5 | 8 | 9 | 7* |
| 1 May 71 | 1.89 | 2.10 | 2.20 | 3.27 | 3.45 | 3.56 | 3.93 | 3.99 | 5.10 |

Table A2 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 6 | 3 | 5 | 4 | 8 | 9* | 7* |
| 20 May 71 | 0.98 | 1.28 | 1.31 | 1.46 | 1.49 | 1.66 | 2.13 | 2.48 | 2.58 |
| | 2 | 3 | 1 | 6 | 5 | 4 | 7* | 8 | 9 |
| 1 June 71 | 0.52 | 0.74 | 0.77 | 0.78 | 0.88 | 1.51 | 2.45 | 3.72 | 4.72 |
| | 1 | 2 | 3 | 9 | 6 | 8 | 4 | 7* | 5 |
| 18 June 71 | 1.31 | 1.85 | 1.97 | 2.54 | 2.64 | 2.65 | 2.71 | 3.35 | 3.66 |
| | 6 | 5 | 4 | 3 | 8 | 2 | 7* | 1 | 9 |
| 2 July 71† | 0.96 | 1.07 | 1.29 | 1.33 | 1.48 | 1.56 | 1.65 | 1.98 | 2.13 |
| | 6 | 1 | 5 | 4 | 8 | 2 | 3 | 9 | 7* |
| 15 July 71 | 0.80 | 0.82 | 1.12 | 1.15 | 1.20 | 1.25 | 1.25 | 1.35 | 1.40 |
| | 3 | 6 | 2 | 5 | 1 | 8 | 4 | 9 | 7* |
| 29 July 71 | 0.78 | 0.79 | 0.84 | 0.84 | 0.85 | 0.88 | 0.90 | 1.19 | 1.33 |
| | 4 | 5 | 3 | 6 | 1 | 2 | 8 | 7* | 9 |
| 17 Aug 71 | 0.68 | 0.71 | 0.76 | 0.81 | 0.82 | 0.89 | 1.27 | 1.37 | 1.44 |
| | 3 | 2 | 4 | 1 | 6 | 5 | 9 | 8 | 7* |
| 2 Sept 71 | 0.71 | 0.77 | 0.79 | 0.81 | 0.84 | 0.93 | 1.03 | 1.07 | 1.28 |
| | 6 | 2 | 3 | 5 | 1 | 4 | 7* | 8 | 9 |
| 16 Sept 71 | 0.61 | 0.66 | 0.66 | 0.76 | 0.79 | 0.85 | 1.04 | 1.06 | 1.26 |
| | 5 | 6 | 3 | 7* | 1 | 4 | 8 | 9 | 2 |
| 2 Oct 71 | 0.75 | 0.76 | 0.99 | 1.08 | 1.09 | 1.15 | 1.20 | 1.46 | 1.74 |

Table A2 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 3 | 4 | 1 | 2 | 8 | 7* | 9 |
| 15 Oct 71† | 0.59 | 0.65 | 0.70 | 0.71 | 0.73 | 0.74 | 1.26 | 1.39 | 1.73 |
| | 5 | 3 | 6 | 2 | 4 | 1 | 8 | 7* | 9 |
| 30 Oct 71 | 0.94 | 1.00 | 1.01 | 1.05 | 1.11 | 1.15 | 1.43 | 1.89 | 1.96 |
| | 3 | 2 | 1 | 4 | 5 | 6 | 8 | 7* | 9 |
| 12 Nov 71 | 0.81 | 1.02 | 1.02 | 1.05 | 1.26 | 1.51 | 1.74 | 2.52 | 4.06 |
| | 7* | 8 | 9 | | | | | | |
| 2 Dec 71 | 1.44 | 1.48 | 2.33 | | | | | | |
| | 3 | 4 | 1 | 7* | 8 | 9 | | | |
| 19 Dec 71 | 0.90 | 0.91 | 0.96 | 3.09 | 3.19 | 4.76 | | | |
| | 3 | 4 | 9 | 8 | 7* | | | | |
| 11 Jan 72 | 1.81 | 3.37 | 7.15 | 7.77 | 9.66 | | | | |
| | 3 | 1 | 8 | 7* | 9 | | | | |
| 18 Feb 72 | 1.40 | 1.46 | 2.89 | 3.08 | 4.32 | | | | |
| | 2 | 1 | 3 | 4 | 5 | 9 | 8 | 7* | |
| 22 Apr 72 | 1.65 | 1.75 | 1.84 | 2.02 | 2.31 | 10.68 | 12.44 | 17.08 | |
| | 3 | 2 | 1 | 4 | 5 | 6 | 9 | 8 | 7* |
| 11 May 72 | 0.60 | 0.74 | 0.94 | 0.94 | 0.96 | 1.73 | 8.40 | 9.00 | 9.46 |
| | 6 | 5 | 7* | 3 | 4 | 8 | 1 | 2 | 9 |
| 31 May 72 | 1.61 | 1.61 | 1.86 | 2.04 | 2.13 | 2.28 | 2.62 | 2.72 | 3.03 |
| | 4 | 2 | 6 | 5 | 8 | 1 | 7* | 3 | 9 |
| 13 June 72 | 1.95 | 2.16 | 2.21 | 2.25 | 2.46 | 2.46 | 2.63 | 3.00 | 4.70 |

Table A2 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 3 | 2 | 1 | 6 | 4 | 8 | 7* | 9 |
| 27 June 72 | 0.62 | 0.64 | 0.67 | 0.84 | 0.84 | 0.92 | 2.95 | 3.63 | 7.00 |
| | 6 | 3 | 7* | 1 | 2 | 8 | 4 | 5 | 9 |
| 12 July 72 | 0.91 | 1.10 | 1.16 | 1.24 | 1.28 | 1.34 | 1.66 | 1.78 | 1.90 |
| | 2 | 3 | 6 | 1 | 4 | 5 | 8 | 7* | 9 |
| 25 July 72 | 0.60 | 0.70 | 0.79 | 0.83 | 0.89 | 0.99 | 1.04 | 1.10 | 1.27 |
| | 1 | 4 | 2 | 5 | 3 | 6 | 7* | 8 | 9 |
| 16 Aug 72 | 0.67 | 0.72 | 0.75 | 0.77 | 0.82 | 1.02 | 1.03 | 1.05 | 1.44 |
| | 6 | 1 | 2 | 3 | 4 | 5 | 7* | 8 | 9 |
| 29 Aug 72 | 0.72 | 0.84 | 0.93 | 1.08 | 1.24 | 1.79 | 2.32 | 2.34 | 7.00 |
| | 4 | 3 | 5 | 2 | 6 | 1 | 7* | 8 | 9 |
| 12 Sept 72 | 1.12 | 1.12 | 1.16 | 1.32 | 1.34 | 1.48 | 1.94 | 2.21 | 3.83 |
| | 2 | 5 | 3 | 1 | 4 | 6 | 7* | 8 | 9 |
| 29 Sept 72 | 1.14 | 2.00 | 2.07 | 2.27 | 2.38 | 4.03 | 7.30 | 7.97 | 8.79 |
| | 3 | 8 | 9 | | | | | | |
| 6 Oct 72 | 2.32 | 6.55 | 10.46 | | | | | | |
| | 2 | 1 | 3 | 5 | 4 | 6 | 8 | 7* | 9 |
| 13 Oct 72 | 1.79 | 1.93 | 2.08 | 2.15 | 2.60 | 2.74 | 4.86 | 4.92 | 5.62 |
| | 5 | 3 | 4 | 6 | 1 | 2 | 8 | 7* | 9 |
| 27 Oct 72 | 0.97 | 1.65 | 1.70 | 1.72 | 1.95 | 2.16 | 6.38 | 6.46 | 7.04 |

Table A2 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 1 | 5 | 6 | 4 | 8 | 7* | 9 |
| 15 Nov 72 | 0.70 | 0.88 | 1.21 | 1.30 | 1.46 | 1.89 | 9.16 | 9.41 | 9.68 |
| | 3 | 1 | 8 | 7 | 9 | | | | |
| 7 Feb 73 | 0.89 | 1.23 | 5.80 | 6.08 | 7.44 | | | | |
| | 5 | 3 | 2 | 4 | 1 | 7 | 8 | 9 | |
| 24 Apr 73 | 1.32 | 1.63 | 1.84 | 1.97 | 2.01 | 3.11 | 3.30 | 4.20 | |
| | 6 | 5 | 1 | 2 | 4 | 3 | 8 | 7 | 9 |
| 11 May 73 | 0.70 | 0.73 | 1.07 | 1.10 | 1.13 | 1.55 | 2.15 | 2.41 | 2.54 |
| | 5 | 2 | 6 | 4 | 1 | 3 | 8 | 9 | 7 |
| 30 May 73 | 1.06 | 1.10 | 1.20 | 1.38 | 1.41 | 1.50 | 5.50 | 5.63 | 5.81 |
| | 1 | 4 | 5 | 2 | 3 | 6 | 8 | 7 | 9 |
| 20 June 73 | 1.27 | 1.39 | 1.64 | 1.76 | 2.17 | 3.30 | 3.36 | 3.40 | 4.87 |
| | 1 | 6 | 2 | 5 | 4 | 3 | 7 | 8 | 9 |
| 6 July 73 | 1.13 | 1.50 | 1.45 | 1.85 | 3.11 | 3.33 | 7.29 | 7.35 | 7.38 |
| | 3 | 4 | 2 | 5 | 1 | 6 | 7 | 8 | 9 |
| 17 July 73 | 0.97 | 1.03 | 1.20 | 1.25 | 1.46 | 1.63 | 1.94 | 2.01 | 2.70 |
| | 6 | 3 | 5 | 1 | 2 | 4 | 8 | 7 | 9 |
| 1 Aug 73 | 1.31 | 1.39 | 1.43 | 1.45 | 1.49 | 1.60 | 2.26 | 2.42 | 4.09 |
| | 3 | 1 | 5 | 2 | 6 | 4 | 7 | 8 | 9 |
| 15 Aug 73 | 1.31 | 1.36 | 1.42 | 1.43 | 1.47 | 1.72 | 1.72 | 1.73 | 3.09 |
| | 6 | 2 | 3 | 1 | 5 | 4 | 8 | 7 | 9 |
| 28 Aug 73 | 0.88 | 0.88 | 0.88 | 0.91 | 1.01 | 1.03 | 1.25 | 1.28 | 1.89 |
| | 3 | 5 | 4 | 2 | 6 | 1 | 7 | 8 | 9 |
| 10 Sept 73 | 0.86 | 0.87 | 0.94 | 0.95 | 1.02 | 1.04 | 1.45 | 1.51 | 3.31 |

Table A2 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 3 | 5 | 4 | 2 | 1 | 8 | 7 | 9 |
| 24 Sept 73 | 0.71 | 0.74 | 0.75 | 0.76 | 0.82 | 0.84 | 1.04 | 1.11 | 2.76 |
| | 5 | 3 | 2 | 4 | 6 | 1 | 8 | 7 | 9 |
| 8 Oct 73 | 0.80 | 0.86 | 0.86 | 0.87 | 0.88 | 0.90 | 1.36 | 1.38 | 2.79 |
| | 1 | 3 | 7 | 8 | 9 | | | | |
| 13 Nov 73 | 0.82 | 0.88 | 1.63 | 1.69 | 2.12 | | | | |
| | 4 | 5 | 2 | 1 | 6 | 3 | 7 | 8 | 9 |
| 3 Apr 74 | 0.88 | 1.08 | 1.30 | 1.45 | 1.55 | 1.79 | 4.11 | 4.53 | 4.71 |
| | 6 | 1 | 2 | 5 | 3 | 4 | 9 | 8 | 7 |
| 17 Apr 74 | 1.07 | 1.58 | 1.64 | 1.64 | 2.09 | 2.88 | 4.04 | 4.15 | 4.27 |
| | 3 | 2 | 4 | 1 | 6 | 5 | 7 | 8 | 9 |
| 7 May 74 | 0.73 | 0.87 | 0.93 | 1.02 | 1.08 | 1.23 | 1.77 | 1.84 | 2.84 |
| | 3 | 4 | 1 | 2 | 5 | 6 | 8 | 9 | 7 |
| 22 May 74 | 1.07 | 1.61 | 1.66 | 1.68 | 1.77 | 4.17 | 4.36 | 5.25 | 5.47 |
| | 4 | 3 | 5 | 7 | 8 | 2 | 1 | 6 | 9 |
| 16 July 74 | 0.54 | 0.62 | 0.66 | 0.72 | 0.74 | 1.00 | 1.01 | 1.04 | 1.85 |
| | 1 | 2 | 3 | 5 | 7 | 4 | 8 | 6 | 9 |
| 31 July 74 | 0.83 | 0.88 | 0.91 | 0.97 | 1.00 | 1.02 | 1.07 | 1.09 | 2.48 |
| | 2 | 1 | 4 | 3 | 5 | 6 | 8 | 7 | 9 |
| 13 Aug 74 | 0.69 | 0.72 | 0.86 | 0.95 | 0.96 | 1.13 | 1.21 | 1.32 | 3.13 |
| | 6 | 5 | 2 | 3 | 1 | 4 | 7 | 8 | 9 |
| 11 Sept 74 | 0.81 | 1.01 | 1.04 | 1.05 | 1.10 | 1.11 | 1.58 | 1.78 | 3.12 |
| | 6 | 5 | 2 | 4 | 1 | 3 | 8 | 7 | 9 |
| 27 Sept 74 | 0.50 | 0.55 | 0.56 | 0.62 | 0.74 | 0.79 | 1.25 | 1.39 | 4.93 |

Table A2 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 1 | 4 | 6 | 3 | 5 | 8 | 7 | 9 |
| 7 Oct 74 | 0.45 | 0.46 | 0.48 | 0.49 | 0.56 | 0.69 | 0.86 | 0.90 | 2.17 |
| | 1 | 4 | 5 | 6 | 2 | 3 | 8 | 7 | 9 |
| 24 Oct 74 | 0.63 | 0.63 | 0.65 | 0.65 | 0.70 | 0.72 | 1.24 | 1.25 | 2.12 |
| | 6 | 5 | 3 | 4 | 2 | 1 | 8 | 7 | 9 |
| 7 Nov 74 | 0.85 | 0.91 | 0.92 | 1.05 | 1.22 | 1.34 | 1.34 | 1.60 | 3.54 |
| | 3 | 6 | 8 | 9 | | | | | |
| 18 Mar 75 | 1.52 | 3.71 | 3.82 | 3.93 | | | | | |
| | 3 | 6 | 8 | 9 | | | | | |
| 22 Apr 75 | 1.59 | 1.60 | 6.18 | 6.33 | | | | | |
| | 3 | 6 | 8 | 9 | | | | | |
| 6 May 75 | 1.13 | 1.82 | 3.98 | 4.18 | | | | | |
| | 6 | 3 | 8 | 9 | | | | | |
| 4 June 75 | 1.70 | 3.27 | 3.60 | 5.21 | | | | | |
| | 3 | 8 | 6 | 9 | | | | | |
| 24 June 75 | 1.81 | 2.29 | 3.07 | 5.24 | | | | | |

Table A3. Mean concentration of nitrate nitrogen in mg/l by station.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 6 | 9 | 2 | 8 | 7* | 3 | 4 | 5 |
| 1 May 70 | 1.43 | 1.63 | 2.32 | 2.47 | 2.70 | 2.80 | 2.97 | 3.07 | 3.62 |
| | 2 | 1 | 3 | 9 | 7* | 6 | 8 | 5 | 4 |
| 15 May 70 | 0.40 | 0.45 | 0.97 | 1.07 | 1.13 | 1.13 | 1.43 | 1.57 | 1.58 |
| | 2 | 1 | 3 | 5 | 6 | 4 | 7* | 8 | 9 |
| 27 May 70 | 0.18 | 0.22 | 0.50 | 0.62 | 0.93 | 1.60 | 1.63 | 2.32 | 4.83 |
| | 7* | 9 | 1 | 8 | 2 | 3 | 6 | 4 | 5 |
| 10 June 70 | 0.47 | 0.58 | 0.77 | 1.37 | 1.37 | 1.47 | 1.97 | 2.47 | 2.88 |
| | 6 | 5 | 1 | 4 | 3 | 2 | 7* | 8 | 9 |
| 23 June 70 | 0.90 | 0.97 | 0.98 | 1.12 | 1.37 | 1.40 | 1.70 | 1.70 | 4.67 |
| | 2 | 7* | 1 | 8 | 9 | 3 | 6 | 5 | 4 |
| 7 July 70 | 0.20 | 0.23 | 0.33 | 0.40 | 0.45 | 0.45 | 0.48 | 0.60 | 0.67 |
| | 8 | 7* | 2 | 1 | 3 | 6 | 4 | 5 | 9 |
| 21 July 70 | 0.15 | 0.17 | 0.22 | 0.25 | 0.28 | 0.30 | 0.30 | 0.37 | 0.88 |
| | 5 | 6 | 2 | 3 | 1 | 7* | 4 | 8 | 9 |
| 4 Aug 70 | 0.12 | 0.12 | 0.16 | 0.18 | 0.18 | 0.20 | 0.23 | 0.55 | 0.73 |
| | 1 | 5 | 4 | 3 | 8 | 2 | 7* | 9 | |
| 18 Aug 70 | 0.08 | 0.09 | 0.10 | 0.12 | 0.13 | 0.14 | 0.19 | 0.21 | |

Table A3 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 1 | 5 | 2 | 6 | 4 | 7* | 8 | 9 |
| 1 Sept 70 | 0.07 | 0.07 | 0.08 | 0.08 | 0.09 | 0.09 | 0.12 | 0.13 | 0.26 |
| | 2 | 1 | 6 | 7* | 5 | 3 | 8 | 9 | 4 |
| 15 Sept 70 | 0.06 | 0.06 | 0.08 | 0.08 | 0.09 | 0.10 | 0.10 | 0.14 | 0.18 |
| | 9 | 3 | 2 | 5 | 4 | 6 | 7* | 1 | 8 |
| 27 Sept 70 | 0.13 | 0.13 | 0.14 | 0.15 | 0.15 | 0.16 | 0.16 | 0.16 | 0.17 |
| | 9 | 4 | 3 | 7* | 8 | 2 | 1 | 6 | 5 |
| 10 Oct 70 | 0.14 | 0.19 | 0.21 | 0.24 | 0.25 | 0.26 | 0.27 | 0.27 | 0.35 |
| | 8 | 1 | 5 | 3 | 7* | 4 | 2 | 6 | 9 |
| 25 Oct 70 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.25 | 0.28 | 0.31 | 0.46 |
| | 7* | 4 | 8 | 2 | 5 | 3 | 6 | 1 | 9 |
| 7 Nov 70 | 0.25 | 0.25 | 0.26 | 0.26 | 0.27 | 0.27 | 0.30 | 0.31 | 0.58 |
| | 2 | 8 | 7* | | | | | | |
| 23 Jan 71 | 0.55 | 0.99 | 1.10 | | | | | | |
| | 1 | 7* | | | | | | | |
| 18 Feb 71 | 0.45 | 0.27 | | | | | | | |
| | 6 | 1 | 2 | 5 | 3 | 4 | 9 | 8 | 7* |
| 16 Apr 71 | 0.30 | 0.47 | 0.50 | 0.64 | 0.67 | 0.96 | 1.47 | 1.75 | 2.43 |
| | 1 | 6 | 2 | 9 | 8 | 4 | 3 | 5 | 7* |
| 1 May 71 | 1.30 | 1.75 | 1.92 | 2.48 | 2.55 | 2.87 | 2.92 | 3.12 | 3.65 |

Table A3 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 9 | 3 | 8 | 6 | 5 | 4 | 7* |
| 20 May 71 | 0.51 | 0.71 | 0.87 | 0.88 | 0.89 | 0.96 | 1.04 | 1.12 | 1.48 |
| | 2 | 3 | 1 | 5 | 6 | 7* | 4 | 8 | 9 |
| 1 June 71 | 0.21 | 0.31 | 0.45 | 0.52 | 0.52 | 0.93 | 1.17 | 2.48 | 3.66 |
| | 1 | 8 | 9 | 2 | 3 | 7* | 4 | 6 | 5 |
| 18 June 71† | 0.68 | 0.84 | 10.1 | 1.18 | 1.27 | 1.43 | 1.96 | 2.00 | 3.03 |
| | 8 | 5 | 9 | 6 | 4 | 7* | 3 | 2 | 1 |
| 2 July 71 | 0.49 | 0.53 | 0.54 | 0.55 | 0.57 | 0.59 | 0.62 | 0.68 | 0.95 |
| | 4 | 7* | 6 | 8 | 1 | 9 | 3 | 5 | 2 |
| 15 July 71† | 0.26 | 0.27 | 0.27 | 0.34 | 0.35 | 0.40 | 0.45 | 0.56 | 0.56 |
| | 1 | 8 | 3 | 4 | 2 | 9 | 5 | 7* | 6 |
| 29 July 71 | 0.08 | 0.08 | 0.08 | 0.10 | 0.12 | 0.13 | 0.14 | 0.16 | 0.16 |
| | 1 | 3 | 2 | 4 | 6 | 5 | 8 | 9 | 7* |
| 17 Aug 71 | 0.07 | 0.08 | 0.08 | 0.08 | 0.09 | 0.10 | 0.11 | 0.14 | 0.16 |
| | 5 | 2 | 3 | 9 | 1 | 8 | 6 | 4 | 7* |
| 2 Sept 71 | 0.07 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.11 | 0.12 | 0.16 |
| | 1 | 8 | 6 | 9 | 7* | 5 | 3 | 2 | 4 |
| 16 Sept 71 | 0.10 | 0.11 | 0.11 | 0.13 | 0.13 | 0.14 | 0.19 | 0.20 | 0.23 |

Table A3 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 4 | 3 | 5 | 8 | 7* | 9 | 2 | 1 |
| 2 Oct 71† | 0.04 | 0.09 | 0.09 | 0.10 | 0.12 | 0.15 | 0.17 | 0.19 | 0.25 |
| | 2 | 1 | 3 | 5 | 6 | 4 | 8 | 7* | 9 |
| 15 Oct 71 | 0.05 | 0.05 | 0.05 | 0.05 | 0.07 | 0.09 | 0.11 | 0.13 | 0.16 |
| | 5 | 6 | 3 | 9 | 4 | 7* | 8 | 2 | 1 |
| 30 Oct 71 | 0.19 | 0.20 | 0.24 | 0.26 | 0.26 | 0.29 | 0.31 | 0.37 | 0.37 |
| | 2 | 3 | 1 | 5 | 6 | 4 | 7* | 8 | 9 |
| 12 Nov 71 | 0.10 | 0.12 | 0.17 | 0.19 | 0.25 | 0.26 | 0.31 | 0.33 | 0.70 |
| | 7* | 8 | 9* | | | | | | |
| 2 Dec 71 | 0.97 | 4.78 | 8.35 | | | | | | |
| | 3 | 4 | 1 | 7* | 8 | 9 | | | |
| 19 Dec 71 | 0.35 | 0.36 | 0.37 | 2.22 | 2.27 | 3.72 | | | |
| | 3 | 4 | 9 | 8 | 7* | | | | |
| 11 Jan 72 | 1.19 | 2.60 | 5.51 | 6.23 | 7.95 | | | | |
| | 1 | 3 | 7* | 8 | 9 | | | | |
| 18 Feb 72 | 0.72 | 0.74 | 1.48 | 1.54 | 2.35 | | | | |
| | 1 | 5 | 4 | 3 | 2 | 9 | 8 | 7* | |
| 22 Apr 72 | 0.74 | 0.75 | 0.82 | 0.86 | 0.89 | 9.37 | 11.12 | 15.4 | |

Table A3 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 2 | 4 | 5 | 1 | 6 | 9 | 8 | 7* |
| 11 May 72 | 0.31 | 0.32 | 0.50 | 0.54 | 0.60 | 1.34 | 7.16 | 7.97 | 8.50 |
| | 7* | 9 | 8 | 6 | 3 | 4 | 5 | 1 | 2 |
| 31 May 72† | 1.00 | 1.14 | 1.14 | 1.37 | 1.54 | 1.59 | 1.72 | 2.03 | 2.11 |
| | 4 | 7* | 8 | 9 | 2 | 5 | 1 | 6 | 3 |
| 13 June 72 | 1.41 | 1.41 | 1.52 | 1.57 | 1.61 | 1.81 | 1.90 | 1.96 | 2.42 |
| | 5 | 2 | 3 | 1 | 6 | 4 | 8 | 7* | 9 |
| 27 June 72 | 0.26 | 0.27 | 0.29 | 0.34 | 0.38 | 0.48 | 1.90 | 2.60 | 4.49 |
| | 1 | 2 | 8 | 6 | 3 | 9 | 4 | 5 | |
| 12 July 72 | 0.20 | 0.25 | 0.46 | 0.54 | 0.54 | 0.57 | 0.94 | 1.22 | |
| | 1 | 8 | 7* | 9 | 3 | 2 | 6 | 5 | 4 |
| 25 July 72† | 0.22 | 0.22 | 0.23 | 0.23 | 0.23 | 0.23 | 0.27 | 0.30 | 0.30 |
| | 1 | 2 | 5 | 4 | 8 | 3 | 7* | 9 | 6 |
| 16 Aug 72† | 0.20 | 0.21 | 0.23 | 0.28 | 0.32 | 0.32 | 0.33 | 0.40 | 0.48 |
| | 2 | 1 | 6 | 3 | 4 | 5 | 8 | 7* | 9 |
| 29 Aug 72 | 0.08 | 0.10 | 0.14 | 0.18 | 0.26 | 0.38 | 0.79 | 0.83 | 3.28 |
| | 1 | 4 | 3 | 5 | 2 | 6 | 8 | 7* | 9 |
| 12 Sept 72 | 0.06 | 0.07 | 0.07 | 0.07 | 0.08 | 0.09 | 0.16 | 0.17 | 0.38 |
| | 2 | 1 | 5 | 3 | 4 | 6 | 7* | 9 | 8 |
| 29 Sept 72† | 0.34 | 0.57 | 0.62 | 0.76 | 0.96 | 2.74 | 5.37 | 5.99 | 6.09 |

Table A3 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 8 | 9 | | | | | | |
| 6 Oct 72 | 0.97 | 4.78 | 8.34 | | | | | | |
| | 2 | 3 | 1 | 5 | 4 | 6 | 8 | 7* | 9 |
| 13 Oct 72 | 0.51 | 0.67 | 0.90 | 1.03 | 1.25 | 1.62 | 3.16 | 3.28 | 3.33 |
| | 5 | 4 | 3 | 6 | 1 | 2 | 8 | 7* | 9 |
| 27 Oct 72 | 0.41 | 0.82 | 0.82 | 0.88 | 1.01 | 1.12 | 4.86 | 4.87 | 5.15 |
| | 2 | 3 | 5 | 1 | 6 | 4 | 8 | 7* | 9 |
| 15 Nov 72 | 0.36 | 0.51 | 0.51 | 0.57 | 0.72 | 1.39 | 7.67 | 7.78 | 8.23 |
| | 3 | 1 | 8 | 7 | 9 | | | | |
| 7 Feb 73 | 0.55 | 0.71 | 4.51 | 4.54 | 6.02 | | | | |
| | 5 | 3 | 2 | 1 | 4 | 7 | 8 | 9 | |
| 24 Apr 73 | 0.72 | 0.97 | 1.10 | 1.22 | 1.24 | 1.83 | 2.05 | 2.67 | |
| | 5 | 6 | 1 | 2 | 4 | 3 | 8 | 7 | 9 |
| 11 May 73 | 0.28 | 0.31 | 0.42 | 0.47 | 0.48 | 0.68 | 1.00 | 1.12 | 1.31 |
| | 2 | 1 | 5 | 3 | 6 | 4 | 8 | 9 | 7 |
| 30 May 73 | 0.34 | 0.36 | 0.37 | 0.39 | 0.42 | 0.54 | 3.75 | 3.90 | 3.91 |
| | 1 | 4 | 2 | 5 | 3 | 7 | 8 | 6 | 9 |
| 20 June 73 | 0.25 | 0.44 | 0.44 | 0.74 | 0.74 | 1.94 | 1.99 | 2.22 | 2.83 |
| | 1 | 2 | 6 | 5 | 4 | 3 | 9 | 7 | 8 |
| 6 July 73 | 0.50 | 0.61 | 0.67 | 1.12 | 1.97 | 2.24 | 5.70 | 5.82 | 5.84 |
| | 4 | 3 | 2 | 5 | 1 | 7 | 8 | 6 | 9 |
| 17 July 73 | 0.31 | 0.38 | 0.46 | 0.52 | 0.59 | 0.79 | 0.84 | 0.85 | 1.17 |
| | 1 | 6 | 3 | 5 | 2 | 4 | 8 | 7 | 9 |
| 1 Aug 73 | 0.64 | 0.70 | 0.72 | 0.74 | 0.77 | 0.80 | 0.98 | 1.01 | 1.28 |

Table A3 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 7 | 3 | 2 | 8 | 5 | 6 | 4 | 9 |
| 15 Aug 73 | 0.30 | 0.39 | 0.43 | 0.45 | 0.52 | 0.57 | 0.61 | 0.85 | 0.86 |
| | 6 | 5 | 3 | 1 | 2 | 4 | 7 | 8 | 9 |
| 28 Aug 73 | 0.03 | 0.04 | 0.08 | 0.11 | 0.13 | 0.16 | 0.28 | 0.29 | 0.56 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 7 | 9 |
| 10 Sept 73 | 0.05 | 0.07 | 0.07 | 0.07 | 0.08 | 0.10 | 0.15 | 0.17 | 0.48 |
| | 6 | 1 | 5 | 2 | 3 | 4 | 8 | 7 | 9 |
| 24 Sept 73 | 0.13 | 0.15 | 0.16 | 0.20 | 0.20 | 0.22 | 0.24 | 0.25 | 0.43 |
| | 1 | 2 | 3 | 5 | 6 | 4 | 7 | 8 | 9 |
| 8 Oct 73 | 0.21 | 0.25 | 0.25 | 0.25 | 0.27 | 0.27 | 0.50 | 0.53 | 0.94 |
| | 1 | 3 | 8 | 7 | 9 | | | | |
| 13 Nov 73 | 0.24 | 0.30 | 0.46 | 0.47 | 0.61 | | | | |
| | 4 | 5 | 2 | 1 | 3 | 6 | 7 | 8 | 9 |
| 3 Apr 74 | 0.50 | 0.67 | 0.77 | 0.87 | 1.06 | 1.11 | 3.19 | 3.46 | 3.75 |
| | 6 | 1 | 2 | 5 | 3 | 4 | 9 | 8 | 7 |
| 17 Apr 74 | 0.75 | 1.05 | 1.18 | 1.22 | 1.53 | 2.23 | 3.01 | 3.21 | 3.27 |
| | 3 | 4 | 1 | 2 | 6 | 5 | 7 | 8 | 9 |
| 7 May 74 | 0.22 | 0.27 | 0.33 | 0.38 | 0.43 | 0.59 | 0.71 | 0.72 | 1.05 |
| | 2 | 1 | 3 | 4 | 5 | 6 | 8 | 9 | 7 |
| 22 May 74 | 0.35 | 0.38 | 0.50 | 0.98 | 1.06 | 3.31 | 3.41 | 4.28 | 4.37 |
| | 4 | 2 | 3 | 7 | 8 | 1 | 5 | 6 | 9 |
| 16 July 74 | 0.15 | 0.16 | 0.20 | 0.21 | 0.22 | 0.23 | 0.25 | 0.33 | 0.36 |
| | 1 | 2 | 3 | 7 | 8 | 4 | 5 | 9 | 6 |
| 31 July 74 | 0.09 | 0.09 | 0.10 | 0.11 | 0.11 | 0.12 | 0.13 | 0.13 | 0.15 |

Table A3 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 4 | 2 | 3 | 7 | 8 | 1 | 9 |
| 13 Aug 74 | 0.05 | 0.05 | 0.07 | 0.09 | 0.09 | 0.13 | 0.13 | 0.15 | 0.30 |
| | 3 | 4 | 2 | 5 | 6 | 1 | 7 | 8 | 9 |
| 11 Sept 74 | 0.10 | 0.10 | 0.11 | 0.11 | 0.14 | 0.15 | 0.22 | 0.26 | 0.30 |
| | 2 | 1 | 3 | 4 | 6 | 8 | 5 | 7 | 9 |
| 27 Sept 74 | 0.05 | 0.06 | 0.08 | 0.08 | 0.12 | 0.15 | 0.16 | 0.18 | 0.69 |
| | 2 | 4 | 1 | 3 | 6 | 5 | 8 | 7 | 9 |
| 7 Oct 74 | 0.06 | 0.07 | 0.08 | 0.08 | 0.08 | 0.09 | 0.12 | 0.15 | 0.33 |
| | 2 | 4 | 5 | 6 | 1 | 7 | 3 | 9 | 8 |
| 24 Oct 74 | 0.09 | 0.12 | 0.12 | 0.12 | 0.13 | 0.15 | 0.17 | 0.28 | 0.40 |
| | 5 | 3 | 6 | 2 | 4 | 1 | 7 | 8 | 9 |
| 7 Nov 74 | 0.20 | 0.25 | 0.26 | 0.28 | 0.28 | 0.31 | 0.35 | 0.36 | 0.52 |
| | 3 | 8 | 9 | 6 | | | | | |
| 18 Mar 75 | 0.93 | 2.75 | 2.82 | 2.84 | | | | | |
| | 6 | 3 | 8 | 9 | | | | | |
| 22 Apr 75 | 0.96 | 0.99 | 4.38 | 4.51 | | | | | |
| | 3 | 6 | 8 | 9 | | | | | |
| 6 May 75 | 0.60 | 0.77 | 2.79 | 3.11 | | | | | |
| | 6 | 3 | 8 | 9 | | | | | |
| 4 June 75 | 1.07 | 2.26 | 2.52 | 3.17 | | | | | |
| | 3 | 8 | 6 | 9 | | | | | |
| 24 June 75 | 1.14 | 1.84 | 2.52 | 3.84 | | | | | |

Table A4. Mean concentration of total Kjeldahl nitrogen in mg/l by station.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 3 | 1 | 2 | 4 | 8 | 5 | 9 | 7* |
| 1 May 70 | 0.51 | 0.77 | 0.77 | 0.77 | 0.90 | 0.91 | 1.04 | 1.32 | 1.33 |
| | 6 | 4 | 1 | 5 | 3 | 2 | 8 | 7* | 9 |
| 15 May 70 | 0.40 | 0.43 | 0.48 | 0.57 | 0.66 | 0.67 | 0.94 | 1.08 | 1.38 |
| | 2 | 1 | 3 | 4 | 6 | 5 | 8 | 9 | 7* |
| 27 May 70 | 0.24 | 0.32 | 0.39 | 0.47 | 0.48 | 0.71 | 1.12 | 1.16 | 1.26 |
| | 2 | 6 | 5 | 1 | 4 | 3 | 8 | 9 | 7* |
| 10 June 70 | 0.51 | 0.52 | 0.65 | 0.66 | 0.73 | 0.78 | 0.98 | 1.50 | 1.64 |
| | 2 | 6 | 5 | 1 | 4 | 3 | 9 | 8 | 7* |
| 23 June 70 | 0.50 | 0.52 | 0.53 | 0.64 | 0.70 | 0.97 | 1.41 | 1.58 | 2.06 |
| | 3 | 6 | 2 | 5 | 4 | 1 | 8 | 9 | 7* |
| 7 July 70† | 0.43 | 0.48 | 0.51 | 0.52 | 0.55 | 0.61 | 1.38 | 0.44 | 1.74 |
| | 3 | 2 | 1 | 4 | 6 | 5 | 9 | 8 | 7* |
| 21 July 70 | 0.43 | 0.49 | 0.57 | 0.57 | 0.62 | 0.63 | 1.30 | 1.31 | 1.81 |
| | 4 | 2 | 1 | 3 | 6 | 5 | 9 | 8 | 7* |
| 4 Aug 70† | 0.49 | 0.50 | 0.53 | 0.57 | 0.60 | 0.65 | 1.18 | 1.27 | 1.56 |
| | 3 | 1 | 2 | 4 | 5 | 9 | 8 | 7* | |
| 18 Aug 70 | 0.47 | 0.48 | 0.49 | 0.55 | 0.68 | 1.31 | 1.33 | 1.76 | |

Table A4 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 2 | 1 | 3 | 9 | 8 | 7* |
| 1 Sept 70 | 0.49 | 0.52 | 0.54 | 0.59 | 0.60 | 0.64 | 1.01 | 1.26 | 1.43 |
| | 3 | 4 | 2 | 6 | 5 | 1 | 9 | 8 | 7* |
| 15 Sept 70 | 0.36 | 0.40 | 0.41 | 0.43 | 0.44 | 0.45 | 0.90 | 1.11 | 1.26 |
| | 3 | 2 | 1 | 5 | 6 | 4 | 9 | 7* | 8 |
| 27 Sept 70 | 0.42 | 0.46 | 0.48 | 0.59 | 0.60 | 0.62 | 1.20 | 1.27 | 1.34 |
| | 5 | 4 | 6 | 1 | 3 | 7* | 2 | 8 | 9 |
| 10 Oct 70† | 0.60 | 0.60 | 0.66 | 0.66 | 0.68 | 0.76 | 0.82 | 1.21 | 1.34 |
| | 4 | 5 | 3 | 6 | 1 | 2 | 9 | 7* | 8 |
| 25 Oct 70 | 0.68 | 0.69 | 0.75 | 0.75 | 0.76 | 0.78 | 1.24 | 1.36 | 1.38 |
| | 4 | 3 | 2 | 6 | 5 | 1 | 7* | 8 | 99 |
| 7 Nov 70 | 0.62 | 0.65 | 0.65 | 0.73 | 0.77 | 0.83 | 0.85 | 1.00 | 1.32 |
| | 2 | 8 | 7* | | | | | | |
| 23 Jan 71 | 0.05 | 0.37 | 0.69 | | | | | | |
| | 1 | 7* | | | | | | | |
| 18 Feb 71 | 0.09 | 0.67 | | | | | | | |
| | 6 | 5 | 2 | 4 | 3 | 1 | 8 | 9 | 7* |
| 16 Apr 71 | 0.20 | 0.28 | 0.38 | 0.39 | 0.48 | 0.50 | 0.75 | 1.21 | 1.23 |
| | 2 | 4 | 5 | 6 | 3 | 1 | 8 | 7* | 9 |
| 1 May 71 | 0.35 | 0.41 | 0.44 | 0.46 | 0.51 | 0.59 | 1.37 | 1.45 | 0.51 |
| | 6 | 5 | 1 | 4 | 2 | 3 | 7* | 8 | 9 |
| 20 May 71 | 0.36 | 0.45 | 0.47 | 0.50 | 0.57 | 0.58 | 1.10 | 1.41 | 1.63 |

Table A4 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 2 | 1 | 4 | 5 | 3 | 9 | 8 | 7* |
| 1 June 71 | 0.26 | 0.31 | 0.33 | 0.34 | 0.37 | 0.44 | 1.09 | 1.42 | 1.52 |
| | 5 | 1 | 6 | 2 | 3 | 4 | 9 | 8 | 7* |
| 18 June 71[†] | 0.63 | 0.63 | 0.64 | 0.68 | 0.71 | 0.75 | 1.53 | 1.81 | 1.92 |
| | 6 | 5 | 3 | 4 | 2 | 8 | 1 | 7* | 9 |
| 2 July 71[†] | 0.41 | 0.55 | 0.71 | 0.72 | 0.87 | 1.00 | 1.03 | 1.07 | 1.59 |
| | 1 | 6 | 5 | 2 | 3 | 8 | 4 | 9 | 7* |
| 15 July 71 | 0.47 | 0.51 | 0.57 | 0.69 | 0.81 | 0.86 | 0.90 | 0.95 | 1.12 |
| | 6 | 3 | 5 | 2 | 1 | 8 | 4 | 9 | 7* |
| 29 July 71 | 0.63 | 0.69 | 0.70 | 0.72 | 0.78 | 0.80 | 0.81 | 1.06 | 1.17 |
| | 4 | 5 | 3 | 6 | 1 | 2 | 8 | 7* | 9 |
| 17 Aug 71 | 0.59 | 0.62 | 0.66 | 0.72 | 0.75 | 0.81 | 1.16 | 1.22 | 1.30 |
| | 3 | 4 | 2 | 1 | 6 | 5 | 9 | 8 | 7* |
| 2 Sept 71 | 0.64 | 0.67 | 0.70 | 0.71 | 0.73 | 0.86 | 0.94 | 0.96 | 1.12 |
| | 2 | 3 | 6 | 4 | 5 | 1 | 7* | 8 | 9 |
| 16 Sept 71 | 0.45 | 0.47 | 0.53 | 0.61 | 0.62 | 0.69 | 0.90 | 0.95 | 1.13 |
| | 5 | 6 | 1 | 3 | 7* | 4 | 8 | 9 | 2 |
| 2 Oct 71 | 0.65 | 0.72 | 0.88 | 0.89 | 0.93 | 1.06 | 1.08 | 1.29 | 1.55 |
| | 5 | 6 | 4 | 3 | 1 | 2 | 8 | 7* | 9 |
| 15 Oct 71 | 0.54 | 0.58 | 0.62 | 0.65 | 0.68 | 0.69 | 1.14 | 1.27 | 1.57 |

Table A4 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 1 | 5 | 3 | 6 | 4 | 8 | 7* | 9 |
| 30 Oct 71 | 0.69 | 0.75 | 0.76 | 0.76 | 0.81 | 0.85 | 1.12 | 1.61 | 1.70 |
| | 3 | 4 | 1 | 2 | 5 | 6 | 8 | 7* | 9* |
| 12 Nov 71 | 0.69 | 0.79 | 0.85 | 0.92 | 1.08 | 1.26 | 1.41 | 2.21 | 3.36 |
| | 7* | 8 | 9 | | | | | | |
| 2 Dec 71 | 0.80 | 0.95 | 1.76 | | | | | | |
| | 4 | 3 | 1 | 8 | 7* | 9 | | | |
| 19 Dec 71 | 0.55 | 0.55 | 0.59 | 0.94 | 0.94 | 1.04 | | | |
| | 3 | 4 | 8 | 9 | 7* | | | | |
| 11 Jan 72 | 0.61 | 0.77 | 1.54 | 1.64 | 1.71 | | | | |
| | 3 | 1 | 8 | 7* | 9 | | | | |
| 18 Feb 72 | 0.66 | 0.74 | 1.35 | 1.60 | 1.98 | | | | |
| | 2 | 3 | 1 | 4 | 9 | 8 | 5 | 7* | |
| 22 Apr 72 | 0.77 | 0.98 | 1.02 | 1.20 | 1.31 | 1.49 | 1.56 | 1.68 | |
| | 3 | 1 | 6 | 2 | 5 | 4 | 7* | 8 | 9 |
| 11 May 72 | 0.29 | 0.34 | 0.39 | 0.42 | 0.43 | 0.45 | 0.96 | 1.03 | 1.25 |
| | 6 | 5 | 3 | 4 | 1 | 2 | 7* | 8 | 9 |
| 31 May 72 | 0.24 | 0.29 | 0.50 | 0.54 | 0.59 | 0.62 | 0.86 | 1.16 | 1.89 |
| | 6 | 5 | 4 | 2 | 1 | 3 | 8 | 7* | 9 |
| 13 June 72 | 0.41 | 0.44 | 0.55 | 0.56 | 0.56 | 0.58 | 1.10 | 1.21 | 3.13 |

Table A4 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 3 | 2 | 4 | 6 | 1 | 8 | 7* | 9 |
| 27 June 72† | 0.35 | 0.36 | 0.40 | 0.44 | 0.46 | 0.50 | 0.86 | 1.03 | 2.50 |
| | 6 | 5 | 3 | 4 | 8 | 2 | 1 | 9 | |
| 12 July 72 | 0.38 | 0.56 | 0.56 | 0.72 | 0.88 | 1.03 | 1.04 | 1.32 | |
| | 2 | 3 | 6 | 4 | 1 | 5 | 8 | 7* | 9 |
| 25 July 72 | 0.37 | 0.47 | 0.53 | 0.59 | 0.61 | 0.69 | 0.82 | 0.88 | 1.05 |
| | 4 | 3 | 1 | 5 | 6 | 2 | 7* | 8 | 9 |
| 16 Aug 72 | 0.45 | 0.50 | 0.54 | 0.54 | 0.55 | 0.55 | 0.71 | 0.73 | 1.04 |
| | 6 | 1 | 2 | 3 | 4 | 5 | 7* | 8 | 9 |
| 29 Aug 72 | 0.57 | 0.74 | 0.85 | 0.90 | 0.98 | 1.41 | 1.49 | 1.56 | 3.72 |
| | 4 | 3 | 5 | 2 | 6 | 1 | 7* | 8 | 9 |
| 12 Sept 72 | 1.06 | 1.06 | 1.09 | 1.23 | 1.25 | 1.42 | 1.77 | 2.05 | 3.45 |
| | 2 | 6 | 3 | 5 | 4 | 1 | 8 | 7* | 9 |
| 29 Sept 72 | 0.80 | 1.27 | 1.32 | 1.32 | 1.41 | 1.70 | 1.88 | 1.93 | 2.81 |
| | 3 | 8 | 9 | | | | | | |
| 6 Oct 72 | 1.35 | 1.77 | 2.11 | | | | | | |
| | 1 | 5 | 6 | 2 | 4 | 3 | 7* | 8 | 9 |
| 13 Oct 72 | 1.04 | 1.12 | 1.12 | 1.29 | 1.35 | 1.41 | 1.64 | 1.70 | 2.34 |

Table A4 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 3 | 6 | 4 | 1 | 2 | 8 | 7* | 9 |
| 27 Oct 72 | 0.57 | 0.83 | 0.84 | 0.88 | 0.94 | 1.04 | 1.52 | 1.59 | 1.89 |
| | 2 | 3 | 4 | 1 | 6 | 5 | 9 | 8 | 7* |
| 15 Nov 72 | 0.34 | 0.37 | 0.51 | 0.64 | 0.74 | 0.79 | 1.42 | 1.49 | 1.63 |
| | 3 | 1 | 8 | 9 | 7 | | | | |
| 7 Feb 73 | 0.34 | 0.51 | 1.29 | 1.42 | 1.54 | | | | |
| | 5 | 3 | 4 | 2 | 1 | 8 | 7 | 9 | |
| 24 Apr 73 | 0.60 | 0.65 | 0.73 | 0.74 | 0.79 | 1.26 | 1.28 | 1.53 | |
| | 6 | 5 | 2 | 1 | 4 | 3 | 8 | 9 | 7 |
| 11 May 73 | 0.39 | 0.45 | 0.63 | 0.65 | 0.65 | 0.87 | 1.15 | 1.23 | 1.29 |
| | 5 | 2 | 6 | 4 | 1 | 3 | 9 | 8 | 7 |
| 30 May 73 | 0.69 | 0.76 | 0.79 | 0.85 | 1.05 | 1.11 | 1.73 | 1.75 | 1.90 |
| | 5 | 4 | 1 | 6 | 2 | 8 | 3 | 7 | 9 |
| 20 June 73 | 0.90 | 0.96 | 1.02 | 1.09 | 1.32 | 1.37 | 1.43 | 1.46 | 2.04 |
| | 1 | 5 | 6 | 2 | 3 | 4 | 7 | 8 | 9 |
| 6 July 73 | 0.64 | 0.73 | 0.83 | 0.84 | 1.09 | 1.15 | 1.46 | 1.51 | 1.68 |
| | 3 | 4 | 5 | 2 | 6 | 1 | 7 | 8 | 9 |
| 17 July 73 | 0.59 | 0.73 | 0.73 | 0.74 | 0.78 | 0.87 | 1.15 | 1.17 | 1.53 |
| | 6 | 3 | 5 | 2 | 4 | 1 | 8 | 7 | 9 |
| 1 Aug 73 | 0.61 | 0.67 | 0.70 | 0.72 | 0.80 | 0.81 | 1.28 | 1.41 | 2.81 |
| | 5 | 6 | 4 | 3 | 2 | 1 | 8 | 7 | 9 |
| 15 Aug 73 | 0.85 | 0.86 | 0.87 | 0.88 | 0.98 | 1.06 | 1.22 | 1.33 | 2.23 |
| | 2 | 1 | 3 | 6 | 4 | 8 | 5 | 7 | 9 |
| 28 Aug 73 | 0.75 | 0.80 | 0.81 | 0.84 | 0.87 | 0.96 | 0.97 | 1.00 | 1.33 |

Table A4 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 2 | 6 | 1 | 7 | 8 | 9 |
| 10 Sept 73 | 0.79 | 0.79 | 0.87 | 0.88 | 0.92 | 0.99 | 1.28 | 1.36 | 2.84 |
| | 3 | 4 | 6 | 5 | 2 | 1 | 8 | 7 | 9 |
| 24 Sept 73 | 0.53 | 0.55 | 0.58 | 0.58 | 0.63 | 0.70 | 0.81 | 0.86 | 2.33 |
| | 5 | 4 | 3 | 2 | 6 | 1 | 8 | 7 | 9 |
| 8 Oct 73 | 0.55 | 0.60 | 0.61 | 0.61 | 0.62 | 0.69 | 0.83 | 0.88 | 1.85 |
| | 3 | 1 | 7 | 8 | 9 | | | | |
| 13 Nov 73 | 0.57 | 0.58 | 1.16 | 1.23 | 1.51 | | | | |
| | 5 | 3 | 6 | 2 | 4 | 8 | 7 | 1 | 9 |
| 14 Mar 74 | 0.66 | 0.74 | 0.79 | 0.84 | 0.97 | 1.29 | 1.39 | 1.43 | 1.47 |
| | 4 | 5 | 6 | 2 | 1 | 3 | 7 | 9 | 8 |
| 3 Apr 74 | 0.37 | 0.40 | 0.43 | 0.53 | 0.59 | 0.73 | 0.92 | 0.95 | 1.07 |
| | 6 | 5 | 2 | 1 | 3 | 4 | 8 | 7 | 9 |
| 17 Apr 74 | 0.32 | 0.41 | 0.45 | 0.53 | 0.56 | 0.65 | 0.93 | 1.00 | 1.03 |
| | 2 | 3 | 5 | 6 | 4 | 1 | 7 | 8 | 9 |
| 7 May 74 | 0.49 | 0.50 | 0.64 | 0.64 | 0.66 | 0.69 | 1.06 | 1.12 | 1.80 |
| | 3 | 4 | 5 | 6 | 8 | 9 | 7 | 1 | 2 |
| 22 May 74 | 0.57 | 0.63 | 0.71 | 0.86 | 0.95 | 0.97 | 1.13 | 1.28 | 1.33 |
| | 4 | 3 | 5 | 7 | 8 | 6 | 1 | 2 | 9 |
| 16 July 74 | 0.39 | 0.41 | 0.41 | 0.51 | 0.52 | 0.71 | 0.78 | 0.84 | 1.49 |
| | 1 | 2 | 3 | 5 | 7 | 4 | 6 | 8 | 9 |
| 31 July 74 | 0.74 | 0.79 | 0.81 | 0.83 | 0.88 | 0.91 | 0.94 | 0.96 | 2.35 |
| | 1 | 2 | 4 | 3 | 5 | 6 | 8 | 7 | 9 |
| 13 Aug 74 | 0.57 | 0.60 | 0.79 | 0.85 | 0.91 | 1.08 | 1.08 | 1.19 | 2.83 |

Table A4 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 5 | 2 | 1 | 3 | 4 | 7 | 8 | 9 |
| 11 Sept 74 | 0.67 | 0.90 | 0.93 | 0.95 | 0.95 | 1.01 | 1.36 | 1.52 | 2.82 |
| | 6 | 5 | 2 | 4 | 1 | 3 | 8 | 7 | 9 |
| 27 Sept 74 | 0.38 | 0.40 | 0.51 | 0.54 | 0.68 | 0.70 | 1.10 | 1.22 | 4.24 |
| | 1 | 2 | 4 | 6 | 3 | 5 | 8 | 7 | 9 |
| 7 Oct 74 | 0.38 | 0.39 | 0.40 | 0.40 | 0.48 | 0.60 | 0.74 | 0.75 | 1.84 |
| | 1 | 4 | 5 | 6 | 3 | 2 | 8 | 7 | 9 |
| 24 Oct 74 | 0.49 | 0.50 | 0.53 | 0.53 | 0.55 | 0.61 | 0.84 | 1.10 | 1.85 |
| | 6 | 3 | 5 | 4 | 2 | 8 | 1 | 7 | 9 |
| 7 Nov 74 | 0.59 | 0.66 | 0.71 | 0.76 | 0.94 | 0.98 | 1.03 | 1.25 | 3.02 |
| | 3 | 6 | 8 | 9 | | | | | |
| 18 Mar 75 | 0.60 | 0.87 | 1.07 | 1.12 | | | | | |
| | 3 | 6 | 8 | 9 | | | | | |
| 22 Apr 75 | 0.60 | 0.64 | 1.80 | 1.82 | | | | | |
| | 3 | 6 | 9 | 8 | | | | | |
| 6 May 75 | 0.53 | 1.05 | 1.07 | 1.19 | | | | | |
| | 6 | 3 | 8 | 9 | | | | | |
| 4 June 75 | 0.63 | 1.01 | 1.08 | 2.04 | | | | | |
| | 8 | 6 | 3 | 9 | | | | | |
| 24 June 75 | 0.44 | 0.55 | 0.68 | 1.41 | | | | | |

Table A5. Mean concentration of ammonia nitrogen in mg/l by station.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 8 | 4 | 5 | 3 | 9 | 6 | 7* | 2 | 1 |
| 1 May 70 | 0.10 | 0.11 | 0.12 | 0.12 | 0.21 | 0.23 | 0.27 | 0.51 | 0.63 |
| | 1 | 5 | 6 | 8 | 3 | 4 | 7* | 9 | 2 |
| 15 May 70 | 0.06 | 0.08 | 0.08 | 0.09 | 0.09 | 0.11 | 0.11 | 0.12 | 0.17 |
| | 1 | 2 | 7* | 6 | 3 | 4 | 9 | 8 | 5 |
| 27 May 70 | 0.15 | 0.19 | 0.22 | 0.29 | 0.31 | 0.35 | 0.38 | 0.51 | 0.54 |
| | 2 | 1 | 6 | 4 | 5 | 3 | 8 | 7* | 9 |
| 10 June 70 | 0.20 | 0.29 | 0.33 | 0.35 | 0.37 | 0.37 | 0.47 | 0.59 | 0.60 |
| | 3 | 5 | 2 | 6 | 4 | 8 | 1 | 9 | 7* |
| 23 June 70 | 0.25 | 0.27 | 0.27 | 0.28 | 0.33 | 0.44 | 0.51 | 0.51 | 0.79 |
| | 7* | 4 | 8 | 3 | 5 | 1 | 6 | 9 | 2 |
| 7 July 70 | 0.14 | 0.16 | 0.18 | 0.18 | 0.20 | 0.22 | 0.23 | 0.29 | 0.30 |
| | 4 | 5 | 1 | 6 | 3 | 7* | 2 | 9 | 8 |
| 10 Oct 70 | 0.47 | 0.50 | 0.53 | 0.59 | 0.63 | 0.71 | 0.75 | 0.88 | 0.95 |
| | 5 | 4 | 8 | 6 | 2 | 3 | 7* | 1 | 9 |
| 25 Oct 70 | 0.56 | 0.59 | 0.67 | 0.69 | 0.69 | 0.69 | 0.73 | 0.74 | 1.08 |
| | 4 | 3 | 2 | 6 | 5 | 1 | 7* | 8 | 9 |
| 7 Nov 70 | 0.56 | 0.57 | 0.59 | 0.64 | 0.70 | 0.72 | 0.78 | 0.91 | 1.23 |

Table A5 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 7* | 8 | | | | | | |
| 23 Jan 71 | 0.01 | 0.12 | 0.13 | | | | | | |
| | 1 | 7* | | | | | | | |
| 18 Feb 71 | 0.01 | 0.12 | | | | | | | |
| | 6 | 4 | 2 | 5 | 3 | 9 | 8 | 1 | 7* |
| 16 Apr 71 | 0.11 | 0.17 | 0.17 | 0.17 | 0.17 | 0.33 | 0.37 | 0.39 | 0.44 |
| | 1 | 5 | 3 | 4 | 2 | 6 | 7* | 8 | 9 |
| 1 May 71$^{\dagger}$ | 0.13 | 0.18 | 0.18 | 0.19 | 0.20 | 0.23 | 0.38 | 0.44 | 0.60 |
| | 2 | 4 | 1 | 5 | 6 | 3 | 8 | 7* | 9 |
| 20 May 71 | 0.09 | 0.11 | 0.11 | 0.12 | 0.18 | 0.23 | 0.49 | 0.50 | 0.52 |
| | 1 | 2 | 6 | 4 | 3 | 5 | 7* | 9 | 8 |
| 1 June 71$^{\dagger}$ | 0.12 | 0.14 | 0.17 | 0.19 | 0.20 | 0.23 | 0.44 | 0.49 | 0.70 |
| | 5 | 2 | 3 | 4 | 6 | 1 | 7* | 9 | 8 |
| 18 June 71 | 0.21 | 0.21 | 0.24 | 0.32 | 0.32 | 0.33 | 0.35 | 0.43 | 0.59 |
| | 6 | 5 | 4 | 2 | 3 | 1 | 8 | 7* | 9 |
| 2 July 71$^{\dagger}$ | 0.14 | 0.18 | 0.18 | 0.27 | 0.27 | 0.27 | 0.33 | 0.42 | 0.50 |
| | 5 | 6 | 1 | 2 | 3 | 4 | 8 | 9 | 7* |
| 15 July 71 | 0.15 | 0.15 | 0.16 | 0.18 | 0.19 | 0.24 | 0.32 | 0.35 | 0.41 |

Table A5 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 3 | 2 | 1 | 4 | 8 | 9 | 7* |
| 29 July 71 | 0.09 | 0.09 | 0.11 | 0.14 | 0.14 | 0.15 | 0.24 | 0.51 | 0.53 |
| | 2 | 6 | 1 | 5 | 3 | 4 | 8 | 7* | 9 |
| 17 Aug 71 | 0.04 | 0.07 | 0.08 | 0.08 | 0.08 | 0.10 | 0.47 | 0.52 | 0.61 |
| | 2 | 6 | 5 | 3 | 1 | 4 | 9 | 7* | 8 |
| 2 Sept 71 | 0.10 | 0.11 | 0.18 | 0.18 | 0.19 | 0.21 | 0.40 | 0.45 | 0.51 |
| | 2 | 3 | 6 | 5 | 4 | 7* | 1 | 8 | 9 |
| 16 Sept 71 | 0.22 | 0.24 | 0.25 | 0.26 | 0.31 | 0.35 | 0.36 | 0.43 | 0.55 |
| | 6 | 3 | 5 | 1 | 4 | 2 | 7* | 8 | 9 |
| 2 Oct 71† | 0.25 | 0.30 | 0.31 | 0.34 | 0.45 | 0.45 | 0.50 | 0.52 | 0.60 |
| | 6 | 5 | 3 | 2 | 1 | 4 | 7* | 8 | 9 |
| 15 Oct 71 | 0.13 | 0.16 | 0.16 | 0.18 | 0.21 | 0.24 | 0.50 | 0.64 | 0.67 |
| | 5 | 2 | 6 | 3 | 1 | 4 | 8 | 7* | 9 |
| 30 Oct 71 | 0.22 | 0.26 | 0.27 | 0.28 | 0.31 | 0.31 | 0.60 | 0.60 | 0.68 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7* | 8 | 9 |
| 12 Nov 71 | 0.23 | 0.25 | 0.26 | 0.27 | 0.28 | 0.31 | 0.55 | 0.55 | 1.04 |
| | 7* | 8 | 9* | | | | | | |
| 2 Dec 71 | 0.50 | 0.56 | 0.94 | | | | | | |
| | 4 | 3 | 1 | 8 | 7* | 9 | | | |
| 19 Dec 71 | 0.27 | 0.28 | 0.36 | 0.57 | 0.58 | 0.63 | | | |
| | 4 | 3 | 9 | 8 | 7* | | | | |
| 11 Jan 72 | 0.36 | 0.39 | 0.72 | 0.88 | 0.93 | | | | |

Table A5 (con't.)

| | 3 | 1 | 7* | 8 | 9 |
|---|---|---|---|---|---|
| 18 Feb 72 | 0.53 | 0.64 | 0.65 | 0.65 | 1.12 |

| | 3 | 2 | 4 | 1 | 5 | 9 | 8 | 7* |
|---|---|---|---|---|---|---|---|---|
| 22 Apr 72 | 0.45 | 0.47 | 0.51 | 0.53 | 0.55 | 0.57 | 0.60 | 0.70 |

| | 3 | 4 | 1 | 6 | 2 | 5 | 7* | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 11 May 72 | 0.15 | 0.15 | 0.16 | 0.17 | 0.18 | 0.22 | 0.52 | 0.53 | 0.59 |

| | 6 | 5 | 4 | 3 | 1 | 2 | 7* | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 31 May 72 | 0.13 | 0.14 | 0.22 | 0.26 | 0.26 | 0.27 | 0.36 | 0.59 | 1.08 |

| | 6 | 5 | 4 | 1 | 3 | 2 | 8 | 7* | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 13 June 72 | 0.01 | 0.02 | 0.03 | 0.09 | 0.09 | 0.11 | 0.54 | 0.54 | 1.46 |

| | 3 | 4 | 5 | 2 | 1 | 6 | 8 | 7* | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 27 June 72 | 0.01 | 0.02 | 0.03 | 0.03 | 0.03 | 0.08 | 0.38 | 0.41 | 1.44 |

| | 6 | 5 | 3 | 4 | 7* | 8 | 2 | 1 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 12 July 72 | 0.15 | 0.16 | 0.23 | 0.31 | 0.35 | 0.36 | 0.36 | 0.42 | 0.51 |

| | 3 | 2 | 6 | 4 | 1 | 5 | 8 | 9 | 7* |
|---|---|---|---|---|---|---|---|---|---|
| 25 July 72 | 0.10 | 0.13 | 0.24 | 0.24 | 0.29 | 0.31 | 0.47 | 0.50 | 0.51 |

| | 5 | 4 | 6 | 3 | 1 | 2 | 7* | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 16 Aug 72 | 0.08 | 0.10 | 0.11 | 0.12 | 0.12 | 0.14 | 0.18 | 0.22 | 0.60 |

| | 4 | 3 | 1 | 6 | 5 | 2 | 7* | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 29 Aug 72 | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.04 | 0.20 | 0.34 | 1.14 |

Table A5 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 5 | 1 | 4 | 3 | 2 | 7* | 8 | 9 |
| 12 Sept 72 | 0.01 | 0.01 | 0.02 | 0.02 | 0.04 | 0.05 | 0.41 | 0.44 | 1.31 |
| | 4 | 6 | 5 | 3 | 1 | 8 | 7* | 2 | 9 |
| 29 Sept 72† | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.20 | 0.22 | 0.25 | 0.60 |
| | 3 | 8 | 9 | | | | | | |
| 6 Oct 72 | 0.01 | 0.23 | 0.48 | | | | | | |
| | 2 | 1 | 4 | 5 | 6 | 3 | 8 | 9 | 7* |
| 13 Oct 72 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.17 | 0.57 | 0.73 |
| | 5 | 6 | 4 | 1 | 3 | 2 | 7* | 8 | 9 |
| 27 Oct 72 | 0.02 | 0.02 | 0.02 | 0.03 | 0.04 | 0.06 | 0.24 | 0.25 | 0.41 |
| | 3 | 8 | 2 | 4 | 9 | 6 | 1 | 5 | 7* |
| 15 Nov 72 | 0.12 | 0.14 | 0.17 | 0.20 | 0.22 | 0.22 | 0.22 | 0.25 | 0.25 |
| | 3 | 1 | 8 | 7 | 9 | | | | |
| 7 Feb 73 | 0.04 | 0.10 | 0.29 | 0.32 | 0.38 | | | | |
| | 4 | 1 | 2 | 5 | 3 | 8 | 7 | 9 | |
| 24 Apr 73 | 0.02 | 0.06 | 0.06 | 0.09 | 0.10 | 0.20 | 0.21 | 0.27 | |
| | 6 | 5 | 4 | 2 | 3 | 1 | 7 | 8 | 9 |
| 11 May 73 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.19 | 0.22 | 0.26 |
| | 2 | 4 | 5 | 6 | 3 | 1 | 8 | 7 | 9 |
| 30 May 73 | 0.01 | 0.01 | 0.01 | 0.01 | 0.03 | 0.08 | 0.31 | 0.32 | 0.35 |
| | 4 | 5 | 3 | 2 | 6 | 1 | 8 | 7 | 9 |
| 20 June 73 | 0.00 | 0.00 | 0.01 | 0.02 | 0.03 | 0.08 | 0.22 | 0.28 | 0.36 |

Table A5 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 5 | 2 | 1 | 7 | 8 | 9 | 4 | 3 |
| 6 July 73 | 0.01 | 0.02 | 0.10 | 0.11 | 0.13 | 0.13 | 0.13 | 0.18 | 0.19 |
| | 4 | 5 | 3 | 6 | 2 | 1 | 7 | 8 | 9 |
| 17 July 73 | 0.02 | 0.03 | 0.04 | 0.05 | 0.05 | 0.09 | 0.09 | 0.21 | 0.36 |
| | 6 | 5 | 3 | 1 | 2 | 4 | 8 | 7 | 9 |
| 1 Aug 73 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.32 | 0.34 | 0.67 |
| | 6 | 1 | 5 | 4 | 2 | 3 | 7 | 8 | 9 |
| 15 Aug 73 | 0.01 | 0.01 | 0.03 | 0.04 | 0.05 | 0.06 | 0.10 | 0.11 | 0.38 |
| | 6 | 3 | 2 | 5 | 1 | 4 | 7 | 9 | 8 |
| 28 Aug 73 | 0.01 | 0.02 | 0.02 | 0.03 | 0.07 | 0.10 | 0.23 | 0.31 | 0.32 |
| | 1 | 4 | 6 | 5 | 3 | 2 | 7 | 8 | 9 |
| 10 Sept 73 | 0.01 | 0.02 | 0.02 | 0.02 | 0.07 | 0.08 | 0.13 | 0.22 | 0.63 |
| | 4 | 5 | 6 | 1 | 2 | 3 | 8 | 7 | 9 |
| 24 Sept 73 | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.03 | 0.04 | 0.08 | 0.45 |
| | 6 | 4 | 3 | 5 | 2 | 1 | 8 | 7 | 9 |
| 8 Oct 73 | 0.01 | 0.02 | 0.03 | 0.03 | 0.03 | 0.07 | 0.11 | 0.11 | 0.52 |
| | 1 | 3 | 7 | 8 | 9 | | | | |
| 13 Nov 73 | 0.01 | 0.03 | 0.23 | 0.24 | 0.25 | | | | |
| | 6 | 1 | 5 | 9 | 2 | 3 | 8 | 7 | |
| 3 Apr 74 | 0.01 | 0.05 | 0.06 | 0.06 | 0.10 | 0.16 | 0.21 | 0.25 | |
| | 5 | 2 | 3 | 1 | 6 | 9 | 4 | 8 | 7 |
| 17 Apr 74 | 0.12 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 | 0.19 | 0.32 | 0.33 |
| | 5 | 6 | 2 | 7 | 8 | 1 | 9 | 3 | 4 |
| 7 May 74 | 0.00 | 0.00 | 0.02 | 0.03 | 0.07 | 0.08 | 0.08 | 0.18 | 0.18 |

Table A5 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 4 | 6 | 3 | 1 | 2 | 9 | 8 | 7 |
| 22 May 74 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.07 | 0.08 | 0.09 | 0.14 |
| | 4 | 2 | 3 | 5 | 8 | 7 | 1 | 6 | 9 |
| 16 July 74 | 0.03 | 0.04 | 0.06 | 0.06 | 0.08 | 0.12 | 0.19 | 0.26 | 0.31 |
| | 2 | 3 | 1 | 6 | 5 | 7 | 8 | 4 | 9 |
| 31 July 74 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.06 | 0.06 | 0.13 | 0.45 |
| | 6 | 5 | 2 | 4 | 1 | 3 | 7 | 8 | 9 |
| 13 Aug 74 | 0.01 | 0.02 | 0.03 | 0.04 | 0.04 | 0.06 | 0.11 | 0.13 | 0.38 |
| | 4 | 3 | 5 | 6 | 2 | 1 | 7 | 8 | 9 |
| 11 Sept 74 | 0.05 | 0.06 | 0.06 | 0.07 | 0.09 | 0.11 | 0.38 | 0.39 | 1.67 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 27 Sept 74 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.17 | 0.25 | 2.49 |
| | 1 | 2 | 3 | 4 | 6 | 5 | 8 | 7 | 9 |
| 7 Oct 74 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.04 | 0.10 | 0.18 | 0.68 |
| | 1 | 2 | 6 | 3 | 4 | 5 | 8 | 7 | 9 |
| 24 Oct 74 | 0.00 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.06 | 0.22 | 0.39 |
| | 5 | 6 | 3 | 4 | 1 | 2 | 8 | 7 | 9 |
| 7 Nov 74 | 0.19 | 0.21 | 0.35 | 0.36 | 0.37 | 0.37 | 0.46 | 0.52 | 1.26 |
| | 3 | 6 | 9 | 8 | | | | | |
| 18 Mar 75 | 0.25 | 0.29 | 0.40 | 0.41 | | | | | |
| | 3 | 6 | 9 | 8 | | | | | |
| 22 Apr 75 | 0.06 | 0.18 | 0.23 | 0.30 | | | | | |
| | 6 | 3 | 9 | 8 | | | | | |
| 6 May 75 | 0.14 | 0.16 | 0.18 | 0.22 | | | | | |
| | 6 | 8 | 3 | 9 | | | | | |
| 4 June 75 | 0.19 | 0.25 | 0.31 | 0.37 | | | | | |

Table A5 (con't.)

| | 3 | 6 | 8 | 9 |
|---|---|---|---|---|
| 24 June 75 | 0.01 | 0.01 | 0.05 | 0.24 |

Table A6. Mean concentration of organic nitrogen in mg/l by station.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 2 | 3 | 1 | 4 | 8 | 5 | 7* | 9 |
| 1 May 70 | 0.29 | 0.34 | 0.54 | 0.59 | 0.78 | 0.86 | 0.92 | 1.06 | 1.07 |
| | 6 | 4 | 1 | 5 | 2 | 3 | 8 | 7* | 9 |
| 15 May 70 | 0.31 | 0.32 | 0.43 | 0.49 | 0.50 | 0.57 | 0.85 | 0.96 | 1.25 |
| | 2 | 3 | 4 | 1 | 5 | 6 | 8 | 9 | 7* |
| 27 May 70 | 0.05 | 0.09 | 0.12 | 0.17 | 0.17 | 0.19 | 0.63 | 0.75 | 1.04 |
| | 6 | 5 | 2 | 1 | 4 | 3 | 8 | 9 | 7* |
| 10 June 70 | 0.21 | 0.28 | 0.32 | 0.37 | 0.38 | 0.41 | 0.50 | 0.90 | 1.04 |
| | 2 | 1 | 6 | 5 | 4 | 9 | 3 | 8 | 7* |
| 23 June 70 | 0.23 | 0.24 | 0.26 | 0.27 | 0.36 | 0.72 | 0.72 | 1.14 | 1.27 |
| | 2 | 6 | 3 | 5 | 1 | 4 | 9 | 8 | 7* |
| 7 July 70$^{\dagger}$ | 0.21 | 0.25 | 0.26 | 0.32 | 0.39 | 0.40 | 1.14 | 1.20 | 1.61 |
| | 7* | 3 | 2 | 6 | 5 | 4 | 1 | 8 | 9 |
| 10 Oct 70 | 0.04 | 0.07 | 0.07 | 0.10 | 0.11 | 0.14 | 0.15 | 0.26 | 0.46 |
| | 3 | 6 | 1 | 2 | 4 | 5 | 9 | 8 | 7* |
| 25 Oct 70 | 0.06 | 0.06 | 0.07 | 0.09 | 0.10 | 0.13 | 0.39 | 0.54 | 0.64 |
| | 2 | 4 | 5 | 7* | 3 | 6 | 8 | 9 | 1 |
| 7 Nov 70 | 0.06 | 0.06 | 0.07 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.11 |
| | 2 | 8 | 7* | | | | | | |
| 23 Jan 71 | 0.04 | 0.24 | 0.57 | | | | | | |

Table A6 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 2 | 4 | 1 | 5 | 6 | 7 | 8 | 9 |
| 7 May 74 | 0.32 | 0.47 | 0.48 | 0.60 | 0.64 | 0.64 | 1.01 | 1.05 | 1.72 |
| | 3 | 4 | 5 | 6 | 8 | 9 | 7 | 1 | 2 |
| 22 May 74 | 0.52 | 0.60 | 0.69 | 0.83 | 0.86 | 0.88 | 0.99 | 1.23 | 1.26 |
| | 3 | 5 | 4 | 7 | 8 | 6 | 1 | 2 | 9 |
| 16 July 74 | 0.35 | 0.35 | 0.36 | 0.39 | 0.43 | 0.45 | 0.59 | 0.80 | 1.18 |
| | 1 | 4 | 2 | 3 | 5 | 7 | 8 | 6 | 9 |
| 31 July 74 | 0.72 | 0.78 | 0.79 | 0.81 | 0.81 | 0.82 | 0.90 | 0.92 | 1.90 |
| | 1 | 2 | 4 | 3 | 5 | 8 | 6 | 7 | 9 |
| 13 Aug 74 | 0.54 | 0.57 | 0.75 | 0.79 | 0.89 | 0.95 | 1.07 | 1.08 | 2.45 |
| | 6 | 1 | 5 | 2 | 3 | 4 | 7 | 8 | 9 |
| 11 Sept 74 | 0.59 | 0.83 | 0.84 | 0.85 | 0.89 | 0.96 | 0.98 | 1.13 | 1.14 |
| | 6 | 5 | 2 | 4 | 1 | 3 | 8 | 7 | 9 |
| 27 Sept 74 | 0.36 | 0.37 | 0.50 | 0.51 | 0.67 | 0.69 | 0.84 | 1.04 | 1.75 |
| | 1 | 2 | 4 | 6 | 3 | 5 | 7 | 8 | 9 |
| 7 Oct 74 | 0.37 | 0.38 | 0.40 | 0.40 | 0.47 | 0.56 | 0.60 | 0.64 | 1.15 |
| | 4 | 1 | 5 | 6 | 3 | 2 | 8 | 7 | 9 |
| 24 Oct 74 | 0.48 | 0.49 | 0.51 | 0.52 | 0.53 | 0.60 | 0.78 | 0.88 | 1.45 |
| | 3 | 6 | 4 | 5 | 2 | 8 | 1 | 7 | 9 |
| 7 Nov 74 | 0.32 | 0.38 | 0.40 | 0.51 | 0.57 | 0.57 | 0.66 | 0.73 | 1.75 |
| | 3 | 6 | 8 | 9 | | | | | |
| 18 Mar 75 | 0.35 | 0.57 | 0.65 | 0.71 | | | | | |
| | 6 | 3 | 8 | 9 | | | | | |
| 22 Apr 75 | 0.46 | 0.53 | 1.50 | 1.59 | | | | | |
| | 3 | 9 | 6 | 8 | | | | | |
| 6 May 75 | 0.37 | 0.89 | 0.91 | 0.97 | | | | | |

Table A6 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 7* | | | | | | | |
| 18 Feb 71 | 0.04 | 0.55 | | | | | | | |
| | 6 | 5 | 1 | 2 | 4 | 3 | 8 | 7* | 9 |
| 16 Apr 71 | 0.09 | 0.13 | 0.20 | 0.21 | 0.22 | 0.31 | 0.52 | 0.79 | 0.88 |
| | 2 | 4 | 6 | 5 | 3 | 1 | 9 | 8 | 7* |
| 1 May 71 | 0.17 | 0.22 | 0.23 | 0.27 | 0.34 | 0.46 | 0.91 | 0.94 | 1.05 |
| | 6 | 5 | 3 | 1 | 4 | 2 | 7* | 8 | 9 |
| 20 May 71 | 0.24 | 0.33 | 0.36 | 0.37 | 0.42 | 0.48 | 0.60 | 0.93 | 1.11 |
| | 6 | 5 | 4 | 2 | 1 | 3 | 9 | 8 | 7* |
| 1 June 71 | 0.10 | 0.14 | 0.16 | 0.17 | 0.21 | 0.22 | 0.60 | 0.72 | 1.71 |
| | 1 | 6 | 5 | 4 | 3 | 2 | 9 | 8 | 7* |
| 18 June 71 | 0.30 | 0.32 | 0.43 | 0.45 | 0.46 | 0.47 | 1.10 | 1.33 | 1.58 |
| | 6 | 5 | 3 | 4 | 2 | 7* | 8 | 1 | 9 |
| 2 July 71† | 0.28 | 0.37 | 0.44 | 0.54 | 0.61 | 0.65 | 0.66 | 0.76 | 1.09 |
| | 1 | 6 | 5 | 2 | 8 | 9 | 3 | 4 | 7* |
| 15 July 71 | 0.32 | 0.36 | 0.42 | 0.51 | 0.54 | 0.60 | 0.62 | 0.66 | 0.72 |
| | 6 | 9 | 8 | 2 | 3 | 5 | 1 | 7* | 4 |
| 29 July 71 | 0.54 | 0.54 | 0.56 | 0.58 | 0.58 | 0.61 | 0.63 | 0.64 | 0.66 |

Table A6 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 3 | 6 | 1 | 8 | 7* | 9 | 2 |
| 17 Aug 71 | 0.49 | 0.54 | 0.58 | 0.66 | 0.68 | 0.69 | 0.69 | 0.70 | 0.78 |
| | 8 | 3 | 4 | 1 | 9 | 6 | 2 | 7* | 5 |
| 2 Sept 71 | 0.45 | 0.46 | 0.46 | 0.52 | 0.54 | 0.58 | 0.59 | 0.67 | 0.68 |
| | 3 | 2 | 6 | 4 | 1 | 5 | 8 | 7* | 9 |
| 16 Sept 71 | 0.24 | 0.24 | 0.28 | 0.31 | 0.33 | 0.36 | 0.53 | 0.56 | 0.58 |
| | 5 | 7* | 6 | 1 | 8 | 3 | 4 | 9 | 2 |
| 2 Oct 71 | 0.35 | 0.44 | 0.47 | 0.55 | 0.56 | 0.59 | 0.61 | 0.70 | 1.09 |
| | 5 | 4 | 6 | 1 | 3 | 8 | 2 | 7* | 9 |
| 15 Oct 71 | 0.38 | 0.38 | 0.45 | 0.47 | 0.49 | 0.50 | 0.51 | 0.77 | 0.90 |
| | 2 | 1 | 3 | 8 | 5 | 6 | 4 | 7* | 9 |
| 30 Oct 71 | 0.42 | 0.45 | 0.51 | 0.52 | 0.54 | 0.54 | 0.55 | 1.00 | 1.02 |
| | 3 | 4 | 1 | 2 | 5 | 8 | 6 | 7* | 9 |
| 12 Nov 71 | 0.43 | 0.52 | 0.62 | 0.70 | 0.80 | 0.86 | 0.95 | 1.67 | 2.33 |
| | 7* | 8 | 9 | | | | | | |
| 2 Dec 71 | 0.30 | 0.31 | 1.48 | | | | | | |
| | 1 | 3 | 4 | 8 | 7* | 9 | | | |
| 19 Dec 71 | 0.23 | 0.27 | 0.27 | 0.36 | 0.36 | 0.42 | | | |
| | 3 | 4 | 8 | 7* | 9 | | | | |
| 11 Jan 72 | 0.22 | 0.41 | 0.66 | 0.78 | 0.92 | | | | |

Table A6 (con't.)

| | 3 | 1 | 8 | 9 | 7* |
|---|---|---|---|---|---|
| 18 Feb 72 | 0.13 | 0.15 | 0.70 | 0.85 | 0.95 |

| | 2 | 1 | 3 | 4 | 9 | 8 | 7* | 5 |
|---|---|---|---|---|---|---|---|---|
| 22 Apr 72 | 0.45 | 0.49 | 0.53 | 0.69 | 0.74 | 0.89 | 0.98 | 1.02 |

| | 3 | 1 | 5 | 6 | 2 | 4 | 7* | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 11 May 72 | 0.14 | 0.18 | 0.20 | 0.22 | 0.24 | 0.30 | 0.44 | 0.50 | 0.67 |

| | 6 | 5 | 3 | 4 | 1 | 2 | 7* | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 31 May 72 | 0.11 | 0.15 | 0.24 | 0.32 | 0.33 | 0.35 | 0.50 | 0.55 | 0.81 |

| | 6 | 5 | 2 | 1 | 3 | 4 | 8 | 7* | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 13 June 72 | 0.40 | 0.42 | 0.44 | 0.48 | 0.49 | 0.51 | 0.57 | 0.67 | 1.67 |

| | 5 | 3 | 2 | 6 | 4 | 1 | 8 | 7* | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 27 June 72$^{\dagger}$ | 0.33 | 0.34 | 0.37 | 0.39 | 0.42 | 0.47 | 0.49 | 0.62 | 1.07 |

| | 6 | 3 | 5 | 4 | 8 | 1 | 2 | 9 |
|---|---|---|---|---|---|---|---|---|
| 12 July 72 | 0.23 | 0.33 | 0.40 | 0.42 | 0.52 | 0.62 | 0.67 | 0.81 |

| | 2 | 6 | 1 | 8 | 4 | 3 | 7* | 5 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 25 July 72$^{\dagger}$ | 0.24 | 0.29 | 0.32 | 0.34 | 0.35 | 0.37 | 0.37 | 0.38 | 0.55 |

| | 4 | 3 | 2 | 1 | 6 | 9 | 5 | 8 | 7* |
|---|---|---|---|---|---|---|---|---|---|
| 16 Aug 72 | 0.34 | 0.38 | 0.41 | 0.42 | 0.43 | 0.44 | 0.46 | 0.50 | 0.53 |

Table A6 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 1 | 2 | 3 | 4 | 8 | 7* | 5 | 9 |
| 29 Aug 72 | 0.55 | 0.72 | 0.80 | 0.88 | 0.96 | 1.22 | 1.29 | 1.38 | 2.58 |
| | 3 | 4 | 5 | 2 | 6 | 7* | 1 | 8 | 9 |
| 12 Sept 72 | 1.02 | 1.04 | 1.08 | 1.19 | 1.24 | 1.36 | 1.40 | 1.61 | 2.14 |
| | 2 | 6 | 3 | 5 | 4 | 1 | 8 | 7* | 9 |
| 29 Sept 72 | 0.55 | 1.24 | 1.28 | 1.35 | 1.40 | 1.67 | 1.68 | 1.71 | 2.20 |
| | 3 | 8 | 9 | | | | | | |
| 6 Oct 72 | 1.33 | 1.54 | 1.63 | | | | | | |
| | 7* | 1 | 5 | 6 | 2 | 4 | 3 | 8 | 9 |
| 13 Oct 72 | 0.90 | 1.01 | 1.09 | 1.09 | 1.27 | 1.33 | 1.38 | 1.53 | 1.77 |
| | 5 | 3 | 6 | 4 | 1 | 2 | 8 | 7* | 9 |
| 27 Oct 72 | 0.55 | 0.79 | 0.83 | 0.86 | 0.91 | 0.99 | 1.27 | 1.35 | 1.49 |
| | 2 | 3 | 4 | 1 | 6 | 5 | 9 | 8 | 7* |
| 15 Nov 72 | 0.17 | 0.25 | 0.31 | 0.42 | 0.52 | 0.54 | 1.21 | 1.35 | 1.39 |
| | 3 | 1 | 8 | 9 | 7 | | | | |
| 7 Feb 73 | 0.30 | 0.41 | 1.00 | 1.04 | 1.22 | | | | |
| | 5 | 3 | 2 | 4 | 1 | 8 | 7 | 9 | |
| 24 Apr 73 | 0.50 | 0.56 | 0.69 | 0.71 | 0.73 | 1.05 | 1.07 | 1.26 | |
| | 6 | 5 | 2 | 1 | 4 | 3 | 8 | 9 | 7 |
| 11 May 73 | 0.39 | 0.44 | 0.61 | 0.63 | 0.64 | 0.85 | 0.93 | 0.97 | 1.09 |

Table A6 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 2 | 6 | 4 | 1 | 3 | 9 | 8 | 7 |
| 30 May 73 | 0.67 | 0.75 | 0.78 | 0.83 | 0.97 | 1.07 | 1.38 | 1.44 | 1.58 |
| | 5 | 1 | 4 | 6 | 8 | 7 | 2 | 3 | 9 |
| 20 June 73 | 0.90 | 0.93 | 0.95 | 1.06 | 1.16 | 1.18 | 1.29 | 1.42 | 1.68 |
| | 1 | 5 | 2 | 6 | 3 | 4 | 7 | 8 | 9 |
| 6 July 73 | 0.51 | 0.71 | 0.74 | 0.82 | 0.90 | 0.97 | 1.34 | 1.38 | 1.55 |
| | 3 | 2 | 5 | 4 | 6 | 1 | 8 | 7 | 9 |
| 17 July 73 | 0.56 | 0.69 | 0.71 | 0.71 | 0.73 | 0.78 | 0.96 | 1.06 | 1.17 |
| | 6 | 3 | 2 | 5 | 4 | 1 | 8 | 7 | 9 |
| 1 Aug 73 | 0.58 | 0.62 | 0.65 | 0.66 | 0.72 | 0.74 | 0.97 | 1.08 | 2.14 |
| | 5 | 3 | 4 | 6 | 2 | 1 | 8 | 7 | 9 |
| 15 Aug 73 | 0.82 | 0.82 | 0.83 | 0.86 | 0.93 | 1.04 | 1.11 | 1.23 | 1.85 |
| | 8 | 1 | 2 | 7 | 4 | 3 | 6 | 5 | 9 |
| 28 Aug 73 | 0.64 | 0.72 | 0.73 | 0.77 | 0.78 | 0.79 | 0.83 | 0.94 | 1.02 |
| | 3 | 5 | 2 | 4 | 6 | 1 | 8 | 7 | 9 |
| 10 Sept 73 | 0.72 | 0.77 | 0.80 | 0.85 | 0.90 | 0.99 | 1.14 | 1.15 | 2.20 |
| | 3 | 4 | 6 | 5 | 2 | 1 | 8 | 7 | 9 |
| 24 Sept 73 | 0.51 | 0.55 | 0.58 | 0.59 | 0.61 | 0.68 | 0.76 | 0.78 | 1.89 |
| | 5 | 4 | 2 | 3 | 6 | 1 | 8 | 7 | 9 |
| 8 Oct 73 | 0.51 | 0.57 | 0.58 | 0.58 | 0.61 | 0.62 | 0.73 | 0.77 | 1.33 |
| | 3 | 1 | 7 | 8 | 9 | | | | |
| 13 Nov 73 | 0.55 | 0.56 | 0.93 | 0.99 | 1.09 | | | | |
| | 4 | 5 | 2 | 6 | 1 | 3 | 7 | 8 | 9 |
| 3 Apr 74 | 0.33 | 0.34 | 0.43 | 0.43 | 0.54 | 0.57 | 0.67 | 0.86 | 0.89 |
| | 6 | 5 | 2 | 1 | 3 | 4 | 8 | 7 | 9 |
| 17 Apr 74 | 0.18 | 0.29 | 0.32 | 0.38 | 0.43 | 0.46 | 0.62 | 0.67 | 0.89 |

Table A6 (con't.)

| | | | | |
|---|---|---|---|---|
| | 6 | 3 | 8 | 9 |
| 4 June 75 | 0.44 | 0.70 | 0.83 | 1.67 |
| | 8 | 6 | 3 | 9 |
| 24 June 75 | 0.39 | 0.54 | 0.66 | 1.16 |

Table A7. Mean concentration of inorganic nitrogen in mg/l by station.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 1 | 9 | 8 | 2 | 7* | 3 | 4 | 5 |
| 1 May 70 | 1.86 | 2.06 | 2.53 | 2.79 | 2.97 | 3.07 | 3.09 | 3.18 | 3.73 |
| | 1 | 2 | 3 | 9 | 6 | 7* | 8 | 5 | 4 |
| 15 May 70 | 0.51 | 0.57 | 1.06 | 1.19 | 1.22 | 1.24 | 1.52 | 1.65 | 1.69 |
| | 1 | 2 | 3 | 5 | 6 | 7* | 4 | 8 | 9 |
| 27 May 70 | 0.37 | 0.38 | 0.81 | 1.16 | 1.22 | 1.85 | 1.95 | 2.82 | 5.17 |
| | 1 | 7* | 9 | 2 | 3 | 8 | 6 | 4 | 5 |
| 10 June 70[†] | 1.06 | 1.06 | 1.18 | 1.56 | 1.84 | 1.84 | 2.29 | 2.75 | 3.25 |
| | 6 | 5 | 4 | 1 | 3 | 2 | 8 | 7* | 9 |
| 23 June 70 | 1.18 | 1.22 | 1.45 | 1.49 | 1.61 | 1.67 | 2.14 | 2.49 | 5.18 |
| | 7* | 2 | 8 | 1 | 3 | 6 | 9 | 5 | 4 |
| 7 July 70 | 0.37 | 0.50 | 0.54 | 0.56 | 0.63 | 0.71 | 0.74 | 0.80 | 0.82 |
| | 4 | 1 | 3 | 6 | 5 | 2 | 9 | 8 | |
| 10 Oct 70 | 0.66 | 0.79 | 0.84 | 0.86 | 0.89 | 1.02 | 1.02 | 1.19 | |
| | 5 | 4 | 8 | 3 | 2 | 7* | 1 | 6 | 9 |
| 25 Oct 70 | 0.80 | 0.84 | 0.91 | 0.93 | 0.97 | 0.97 | 0.98 | 1.00 | 1.54 |
| | 4 | 3 | 2 | 6 | 5 | 7* | 1 | 8 | 9 |
| 7 Nov 70 | 0.81 | 0.84 | 0.85 | 0.95 | 0.96 | 1.03 | 1.04 | 1.17 | 1.81 |

Table A7 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 8 | 7* | | | | | | |
| 23 Jan 71 | 0.56 | 1.11 | 1.22 | | | | | | |
| | 1 | 7* | | | | | | | |
| 18 Feb 71 | 0.46 | 1.39 | | | | | | | |
| | 6 | 2 | 5 | 3 | 1 | 4 | 9 | 8 | 7* |
| 16 Apr 71 | 0.41 | 0.67 | 0.81 | 0.85 | 0.87 | 1.12 | 1.80 | 2.11 | 2.87 |
| | 1 | 6 | 2 | 8 | 9 | 4 | 3 | 5 | 7* |
| 1 May 71† | 1.40 | 1.97 | 2.12 | 2.99 | 3.05 | 3.06 | 3.13 | 3.30 | 4.03 |
| | 1 | 2 | 3 | 6 | 5 | 4 | 8 | 9 | 7* |
| 20 May 71 | 0.62 | 0.80 | 1.10 | 1.14 | 1.16 | 1.22 | 1.38 | 1.39 | 1.98 |
| | 2 | 3 | 1 | 5 | 6 | 4 | 7* | 8 | 9 |
| 1 June 71 | 0.35 | 0.51 | 0.57 | 0.74 | 1.19 | 1.36 | 1.37 | 3.19 | 4.15 |
| | 1 | 2 | 8 | 9 | 3 | 7* | 4 | 6 | 5 |
| 18 June 71 | 1.00 | 1.39 | 1.44 | 1.44 | 1.51 | 1.78 | 2.28 | 2.32 | 3.23 |
| | 6 | 5 | 4 | 8 | 3 | 2 | 7* | 9 | 1 |
| 2 July 71 | 0.69 | 0.70 | 0.75 | 0.82 | 0.89 | 0.96 | 1.00 | 1.05 | 1.22 |
| | 6 | 4 | 1 | 3 | 8 | 7* | 5 | 2 | 9 |
| 15 July 71 | 0.43 | 0.50 | 0.51 | 0.63 | 0.66 | 0.68 | 0.71 | 0.74 | 0.74 |
| | 3 | 1 | 5 | 4 | 6 | 2 | 8 | 9 | 7* |
| 29 July 71 | 0.19 | 0.22 | 0.23 | 0.25 | 0.25 | 0.26 | 0.32 | 0.65 | 0.69 |

Table A7 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 1 | 6 | 3 | 5 | 4 | 8 | 7* | 9 |
| 17 Aug 71 | 0.12 | 0.14 | 0.16 | 0.16 | 0.17 | 0.19 | 0.59 | 0.68 | 0.74 |
| | 2 | 5 | 3 | 6 | 1 | 4 | 9 | 7* | 8 |
| 2 Sept 71 | 0.17 | 0.25 | 0.26 | 0.26 | 0.29 | 0.33 | 0.49 | 0.61 | 0.62 |
| | 6 | 5 | 2 | 3 | 1 | 7* | 8 | 4 | 9 |
| 16 Sept 71 | 0.36 | 0.41 | 0.42 | 0.43 | 0.46 | 0.48 | 0.53 | 0.54 | 0.68 |
| | 6 | 3 | 5 | 4 | 1 | 8 | 2 | 7* | 9 |
| 2 Oct 71 | 0.29 | 0.39 | 0.41 | 0.54 | 0.58 | 0.64 | 0.65 | 0.65 | 0.76 |
| | 6 | 5 | 3 | 2 | 1 | 4 | 7* | 8 | 9 |
| 15 Oct 71 | 0.20 | 0.21 | 0.21 | 0.23 | 0.26 | 0.33 | 0.63 | 0.76 | 0.83 |
| | 5 | 6 | 3 | 4 | 2 | 1 | 7* | 8 | 9 |
| 30 Oct 71 | 0.41 | 0.47 | 0.52 | 0.57 | 0.63 | 0.68 | 0.89 | 0.91 | 0.94 |
| | 2 | 3 | 1 | 5 | 4 | 6 | 7* | 8 | 9* |
| 12 Nov 71 | 0.36 | 0.38 | 0.40 | 0.46 | 0.53 | 0.56 | 0.85 | 0.88 | 1.73 |
| | 7* | 8 | 9* | | | | | | |
| 2 Dec 71 | 1.47 | 5.34 | 9.28 | | | | | | |
| | 3 | 4 | 1 | 7* | 8 | 9 | | | |
| 19 Dec 71 | 0.63 | 0.64 | 0.73 | 2.79 | 2.84 | 4.35 | | | |
| | 3 | 4 | 9 | 8 | 7* | | | | |
| 11 Jan 72 | 1.59 | 2.96 | 6.23 | 7.11 | 8.88 | | | | |
| | 3 | 1 | 7* | 8 | 9 | | | | |
| 18 Feb 72 | 1.27 | 1.31 | 2.12 | 2.23 | 3.47 | | | | |

Table A7 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 5 | 3 | 4 | 2 | 9 | 8 | 7* | |
| 22 Apr 72 | 1.27 | 1.29 | 1.31 | 1.33 | 1.36 | 9.94 | 10.59 | 16.10 | |
| | 3 | 2 | 4 | 1 | 5 | 6 | 9 | 8 | 7* |
| 11 May 72 | 0.46 | 0.50 | 0.65 | 0.75 | 0.76 | 1.51 | 7.75 | 8.51 | 9.02 |
| | 7* | 6 | 8 | 3 | 4 | 5 | 9 | 1 | 2 |
| 31 May 72 | 1.36 | 1.49 | 1.73 | 1.80 | 1.81 | 1.86 | 2.22 | 2.29 | 2.38 |
| | 4 | 2 | 5 | 7* | 6 | 1 | 8 | 3 | 9 |
| 13 June 72 | 1.44 | 1.72 | 1.83 | 1.95 | 1.97 | 1.99 | 2.06 | 2.51 | 3.03 |
| | 5 | 3 | 2 | 1 | 6 | 4 | 8 | 7* | 9 |
| 27 June 72 | 0.29 | 0.30 | 0.30 | 0.37 | 0.45 | 0.50 | 2.27 | 3.01 | 5.93 |
| | 2 | 7* | 1 | 6 | 3 | 8 | 9 | 4 | 5 |
| 12 July 72 | 0.61 | 0.62 | 0.62 | 0.68 | 0.77 | 0.82 | 1.08 | 1.25 | 1.38 |
| | 3 | 2 | 6 | 1 | 4 | 5 | 8 | 9 | 7* |
| 25 July 72 | 0.33 | 0.36 | 0.50 | 0.51 | 0.55 | 0.61 | 0.70 | 0.73 | 0.74 |
| | 5 | 1 | 2 | 4 | 3 | 7* | 8 | 6 | 9 |
| 16 Aug 72[†] | 0.31 | 0.32 | 0.35 | 0.38 | 0.44 | 0.50 | 0.54 | 0.59 | 1.00 |
| | 1 | 2 | 6 | 3 | 4 | 5 | 7* | 8 | 9 |
| 29 Aug 72 | 0.12 | 0.12 | 0.17 | 0.21 | 0.27 | 0.42 | 1.03 | 1.12 | 4.42 |
| | 1 | 5 | 4 | 6 | 3 | 2 | 7* | 8 | 9 |
| 12 Sept 72 | 0.08 | 0.08 | 0.09 | 0.10 | 0.11 | 0.13 | 0.58 | 0.60 | 1.70 |

Table A7 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 1 | 5 | 3 | 4 | 6 | 7* | 8 | 9 |
| 29 Sept 72 | 0.59 | 0.60 | 0.65 | 0.80 | 0.98 | 2.77 | 5.59 | 6.29 | 6.59 |
| | 3 | 8 | 9 | | | | | | |
| 6 Oct 72 | 0.99 | 5.01 | 8.41 | | | | | | |
| | 2 | 3 | 1 | 5 | 4 | 6 | 8 | 9 | 7* |
| 13 Oct 72 | 0.52 | 0.71 | 0.92 | 1.06 | 1.27 | 1.65 | 3.33 | 3.91 | 4.02 |
| | 5 | 4 | 3 | 6 | 1 | 2 | 8 | 7* | 9 |
| 27 Oct 72 | 0.42 | 0.84 | 0.86 | 0.89 | 1.04 | 1.04 | 5.11 | 5.11 | 5.56 |
| | 2 | 3 | 5 | 1 | 6 | 4 | 8 | 7* | 9 |
| 15 Nov 72 | 0.53 | 0.63 | 0.76 | 0.79 | 0.94 | 1.59 | .82 | 8.03 | 8.47 |
| | 3 | 1 | 8 | 7 | 4 | | | | |
| 7 Feb 73 | 0.60 | 0.82 | 4.80 | 4.86 | 6.40 | | | | |
| | 5 | 3 | 2 | 4 | 1 | 7 | 8 | 9 | |
| 24 Apr 73 | 0.81 | 1.07 | 1.15 | 1.26 | 1.28 | 2.04 | 2.25 | 2.94 | |
| | 5 | 6 | 1 | 2 | 4 | 3 | 8 | 7 | 9 |
| 11 May 73 | 0.29 | 0.32 | 0.45 | 0.49 | 0.49 | 0.70 | 1.22 | 1.31 | 1.57 |
| | 2 | 5 | 3 | 6 | 1 | 4 | 8 | 7 | 9 |
| 30 May 73 | 0.35 | 0.38 | 0.42 | 0.42 | 0.44 | 0.55 | 4.06 | 4.23 | 4.25 |
| | 1 | 4 | 2 | 5 | 3 | 8 | 7 | 6 | 9 |
| 20 June 73 | 0.33 | 0.44 | 0.47 | 0.74 | 0.76 | 2.21 | 2.22 | 2.25 | 3.19 |
| | 1 | 6 | 2 | 5 | 4 | 3 | 9 | 7 | 8 |
| 6 July 73 | 0.61 | 0.68 | 0.71 | 1.13 | 2.14 | 2.43 | 5.83 | 5.95 | 5.97 |

Table A7 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 3 | 2 | 5 | 1 | 7 | 6 | 8 | 9 |
| 17 July 73 | 0.32 | 0.41 | 0.51 | 0.55 | 0.68 | 0.88 | 0.90 | 1.05 | 1.52 |
| | 1 | 6 | 3 | 5 | 2 | 4 | 8 | 7 | 9 |
| 1 Aug 73 | 0.70 | 0.73 | 0.77 | 0.77 | 0.84 | 0.88 | 1.29 | 1.34 | 1.95 |
| | 1 | 3 | 7 | 2 | 5 | 6 | 8 | 4 | 9 |
| 15 Aug 73 | 0.31 | 0.49 | 0.49 | 0.50 | 0.60 | 0.62 | 0.63 | 0.89 | 1.24 |
| | 6 | 5 | 3 | 2 | 1 | 4 | 7 | 8 | 9 |
| 28 Aug 73 | 0.04 | 0.07 | 0.09 | 0.15 | 0.19 | 0.25 | 0.51 | 0.61 | 0.87 |
| | 1 | 4 | 5 | 6 | 3 | 2 | 7 | 8 | 9 |
| 10 Sept 73 | 0.06 | 0.09 | 0.10 | 0.12 | 0.14 | 0.15 | 0.30 | 0.37 | 1.11 |
| | 6 | 1 | 5 | 2 | 4 | 3 | 8 | 7 | 9 |
| 24 Sept 73 | 0.13 | 0.15 | 0.17 | 0.22 | 0.22 | 0.23 | 0.28 | 0.33 | 0.88 |
| | 6 | 1 | 3 | 2 | 4 | 5 | 7 | 8 | 9 |
| 8 Oct 73 | 0.28 | 0.28 | 0.28 | 0.28 | 0.29 | 0.29 | 0.61 | 0.63 | 1.46 |
| | 1 | 3 | 7 | 8 | 9 | | | | |
| 13 Nov 73 | 0.25 | 0.33 | 0.70 | 0.70 | 0.86 | | | | |
| | 4 | 5 | 2 | 1 | 6 | 3 | 7 | 8 | 9 |
| 3 Apr 74 | 0.55 | 0.74 | 0.87 | 0.91 | 1.12 | 1.22 | 3.44 | 3.67 | 3.82 |
| | 6 | 1 | 2 | 5 | 3 | 4 | 9 | 8 | 7 |
| 17 Apr 74 | 0.89 | 1.19 | 1.32 | 1.34 | 1.66 | 2.24 | 3.15 | 3.53 | 3.60 |
| | 2 | 3 | 1 | 6 | 4 | 5 | 7 | 8 | 9 |
| 7 May 74 | 0.40 | 0.40 | 0.41 | 0.43 | 0.45 | 0.59 | 0.76 | 0.80 | 1.13 |
| | 2 | 1 | 3 | 4 | 5 | 6 | 8 | 9 | 7 |
| 22 May 74 | 0.42 | 0.43 | 0.55 | 1.00 | 1.08 | 3.34 | 3.50 | 4.37 | 4.51 |
| | 4 | 2 | 3 | 8 | 5 | 7 | 1 | 6 | 9 |
| 16 July 74 | 0.18 | 0.20 | 0.26 | 0.30 | 0.31 | 0.33 | 0.42 | 0.59 | 0.67 |

Table A7 (con't.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | 1 | 3 | 5 | 6 | 7 | 8 | 4 | 9 |
| 31 July 74 | 0.09 | 0.11 | 0.11 | 0.16 | 0.17 | 0.17 | 0.17 | 0.25 | 0.59 |
| | 6 | 5 | 4 | 2 | 3 | 1 | 7 | 8 | 9 |
| 13 Aug 74 | 0.06 | 0.07 | 0.11 | 0.12 | 0.15 | 0.18 | 0.24 | 0.26 | 0.68 |
| | 4 | 3 | 5 | 2 | 6 | 1 | 7 | 8 | 9 |
| 11 Sept 74 | 0.15 | 0.16 | 0.17 | 0.19 | 0.21 | 0.26 | 0.60 | 0.65 | 1.97 |
| | 2 | 1 | 3 | 4 | 6 | 5 | 7 | 8 | 9 |
| 27 Sept 74 | 0.06 | 0.07 | 0.10 | 0.11 | 0.15 | 0.18 | 0.35 | 0.40 | 3.18 |
| | 2 | 4 | 6 | 1 | 3 | 5 | 8 | 7 | 9 |
| 7 Oct 74 | 0.07 | 0.08 | 0.09 | 0.09 | 0.09 | 0.13 | 0.23 | 0.33 | 1.01 |
| | 2 | 6 | 1 | 4 | 5 | 3 | 7 | 8 | 9 |
| 24 Oct 74 | 0.10 | 0.13 | 0.14 | 0.14 | 0.14 | 0.19 | 0.37 | 0.46 | 0.67 |
| | 5 | 6 | 3 | 4 | 2 | 1 | 8 | 7 | 9 |
| 7 Nov 74 | 0.40 | 0.47 | 0.60 | 0.64 | 0.65 | 0.68 | 0.82 | 0.87 | 1.79 |
| | 3 | 6 | 8 | 9 | | | | | |
| 18 Mar 75 | 1.18 | 3.14 | 3.16 | 3.22 | | | | | |
| | 3 | 6 | 8 | 9 | | | | | |
| 22 Apr 75 | 1.06 | 1.14 | 4.69 | 4.74 | | | | | |
| | 3 | 6 | 8 | 9 | | | | | |
| 6 May 75 | 0.76 | 0.91 | 3.01 | 3.29 | | | | | |
| | 6 | 3 | 8 | 9 | | | | | |
| 4 June 75 | 1.26 | 2.56 | 2.77 | 3.54 | | | | | |
| | 3 | 8 | 6 | 9 | | | | | |
| 24 June 75 | 1.15 | 1.89 | 2.54 | 4.08 | | | | | |

Table A8. Seasonal and annual means of chloride concentrations in mg/l by stations.

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1970 | 20.4 | 19.7 | 20.4 | 21.4 | 19.7 | 19.7 | 20.2 | 31.1 | 27.9 | 28.6 | 29.3 |
| Summer 1970 | 25.1 | 24.2 | 24.1 | 26.1 | 25.1 | 20.6 | 24.2 | 31.9 | 30.7 | 33.8 | 32.1 |
| Fall 1970 | 22.7 | 22.0 | 21.6 | 22.1 | 23.4 | 19.1 | 21.8 | 23.9 | 27.3 | 33.6 | 28.2 |
| 1970 Mean | 22.7 | 22.0 | 22.0 | 23.2 | 22.7 | 19.8 | 22.1 | 29.0 | 28.6 | 32.0 | 29.2 |
| Spring 1972 | 23.2 | 20.8 | 22.6 | 24.9 | 22.7 | 19.6 | 22.3 | 38.7 | 32.3 | 41.5 | 37.5 |
| Summer 1972 | 16.3 | 15.3 | 16.6 | 17.8 | 17.5 | 16.6 | 16.7 | 21.5 | 21.9 | 39.7 | 27.7 |
| Fall 1972 | 17.6 | 15.2 | 16.5 | 17.5 | 16.6 | 17.4 | 16.8 | 33.7 | 31.8 | 41.4 | 35.6 |
| 1972 Mean | 19.0 | 17.1 | 18.6 | 20.1 | 18.9 | 17.9 | 18.6 | 31.3 | 28.7 | 40.9 | 33.6 |
| Spring 1973 | 17.7 | 17.1 | 18.4 | 17.8 | 16.6 | 17.6 | 17.5 | 26.3 | 25.7 | 28.9 | 27.0 |
| Summer 1973 | 16.4 | 15.8 | 16.2 | 16.2 | 16.2 | 17.0 | 16.3 | 22.2 | 21.3 | 36.8 | 26.8 |
| Fall 1973 | 14.4 | 13.4 | 14.3 | 14.6 | 14.4 | 15.1 | 14.7 | 19.9 | 19.9 | 34.7 | 24.8 |
| 1973 Mean | 16.2 | 15.4 | 16.3 | 16.2 | 16.4 | 16.6 | 16.2 | 22.8 | 22.3 | 33.5 | 26.2 |

Table A8 (con't.)

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1974 | 18.5 | 18.3 | 18.2 | 19.2 | 20.0 | 21.4 | 19.3 | 28.6 | 27.0 | 29.8 | 28.5 |
| Summer 1974 | 17.5 | 16.6 | 18.2 | 19.6 | 18.9 | 18.3 | 18.2 | 21.2 | 20.5 | 42.2 | 28.0 |
| Fall 1974 | 16.8 | 16.3 | 17.0 | 15.2 | 13.6 | 12.2 | 15.2 | 20.2 | 20.5 | 34.1 | 24.9 |
| 1974 Mean | 17.6 | 17.1 | 17.8 | 18.0 | 17.5 | 17.3 | 17.5 | 23.3 | 22.7 | 35.4 | 27.1 |
| Spring 1975 |  | 19.7 |  |  |  | 21.2 | 20.5 |  | 27.6 | 33.2 | 30.4 |
| Spring Mean | 20.0 | 19.0 | 19.9 | 20.8 | 19.8 | 19.6 | 19.8 | 31.2 | 28.2 | 32.2 | 30.6 |
| Summer Mean | 18.8 | 18.0 | 18.8 | 19.9 | 19.4 | 18.1 | 18.9 | 24.2 | 23.6 | 38.1 | 28.7 |
| Fall Mean | 17.9 | 16.7 | 17.4 | 17.4 | 17.0 | 16.0 | 17.1 | 24.4 | 24.9 | 36.0 | 28.4 |

Table A9. Seasonal and annual means of total nitrogen concentrations in mg/l by stations.

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1970 | 1.35 | 1.70 | 2.17 | 2.57 | 2.63 | 1.80 | 2.04 | 3.12 | 3.02 | 4.06 | 3.40 |
| Summer 1970 | 0.75 | 0.67 | 0.73 | 0.81 | 0.85 | 0.75 | 0.76 | 1.84 | 1.58 | 1.77 | 1.73 |
| Fall 1970 | 0.83 | 0.83 | 0.76 | 0.79 | 0.85 | 0.86 | 0.82 | 1.29 | 1.39 | 1.49 | 1.39 |
| 1970 Mean | 0.98 | 1.07 | 1.22 | 1.39 | 1.44 | 1.14 | 1.21 | 2.08 | 2.00 | 2.44 | 2.17 |
| Spring 1971 | 1.19 | 1.33 | 1.76 | 2.10 | 2.10 | 1.49 | 1.99 | 3.35 | 3.06 | 3.27 | 3.23 |
| Summer 1971 | 1.06 | 1.06 | 0.97 | 0.96 | 0.93 | 0.84 | 1.16 | 1.41 | 1.18 | 1.43 | 1.34 |
| Fall 1971 | 0.96 | 1.04 | 0.84 | 0.97 | 0.86 | 0.91 | 1.12 | 1.58 | 1.34 | 2.56 | 1.83 |
| 1971 Mean | 1.07 | 1.14 | 1.19 | 1.34 | 1.30 | 1.08 | 1.42 | 2.11 | 1.86 | 2.42 | 2.13 |
| Spring 1972 | 1.72 | 1.59 | 1.62 | 1.59 | 1.55 | 1.60 | 1.61 | 6.98 | 5.82 | 6.76 | 6.52 |
| Summer 1972 | 1.01 | 0.98 | 0.96 | 1.13 | 1.30 | 0.96 | 1.06 | 1.51 | 1.60 | 3.09 | 2.07 |
| Fall 1972 | 1.84 | 1.16 | 1.80 | 2.14 | 1.61 | 2.49 | 1.84 | 7.02 | 6.98 | 8.33 | 7.44 |
| 1972 Mean | 1.52 | 1.24 | 1.46 | 1.62 | 1.49 | 1.68 | 1.50 | 5.17 | 4.80 | 6.06 | 5.34 |

Table A9 (con't.)

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1973 | 1.43 | 1.45 | 1.71 | 1.47 | 1.19 | 1.74 | 1.49 | 3.68 | 3.59 | 4.31 | 3.86 |
| Summer 1973 | 1.29 | 1.25 | 1.14 | 1.35 | 1.28 | 1.33 | 1.28 | 1.85 | 1.82 | 2.95 | 2.21 |
| Fall 1973 | 0.90 | 0.87 | 0.84 | 0.86 | 0.80 | 0.86 | 0.87 | 1.40 | 1.39 | 2.70 | 1.83 |
| 1973 Mean | 1.21 | 1.19 | 1.23 | 1.23 | 1.10 | 1.31 | 1.21 | 2.31 | 2.27 | 3.32 | 2.63 |
| Spring 1974 | 1.43 | 1.47 | 1.42 | 1.58 | 1.43 | 1.99 | 1.54 | 3.92 | 3.72 | 4.22 | 3.95 |
| Summer 1974 | 0.92 | 0.90 | 0.88 | 0.88 | 0.90 | 0.98 | 0.91 | 1.16 | 1.20 | 2.64 | 1.67 |
| Fall 1974 | 0.80 | 0.73 | 0.75 | 0.69 | 0.70 | 0.63 | 0.72 | 1.29 | 1.19 | 3.20 | 1.90 |
| 1974 Mean | 1.05 | 1.00 | 1.02 | 1.05 | 1.01 | 1.20 | 1.04 | 2.12 | 2.04 | 3.37 | 2.50 |
| Spring 1975 |  |  | 1.93 |  |  | 2.58 | 2.26 |  | 3.42 | 4.65 | 4.04 |
| Spring Mean | 1.42 | 1.51 | 1.74 | 1.86 | 1.78 | 1.72 | 1.73 | 4.21 | 3.84 | 4.52 | 4.19 |
| Summer Mean | 1.01 | 0.97 | 0.94 | 1.03 | 1.05 | 0.97 | 1.03 | 1.55 | 1.48 | 2.38 | 1.80 |
| Fall Mean | 1.07 | 0.93 | 1.00 | 1.09 | 0.96 | 1.15 | 1.07 | 2.52 | 2.46 | 3.66 | 2.88 |

Table A10. Seasonal and annual means of nitrate nitrogen concentrations in mg/l by stations.

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1970 | 0.77 | 1.16 | 1.46 | 1.97 | 1.93 | 1.31 | 1.43 | 1.55 | 1.90 | 2.69 | 2.05 |
| Summer 1970 | 0.18 | 0.16 | 0.22 | 0.28 | 0.25 | 0.25 | 0.22 | 0.18 | 0.27 | 0.51 | 0.32 |
| Fall 1970 | 0.21 | 0.20 | 0.19 | 0.20 | 0.23 | 0.23 | 0.21 | 0.19 | 0.20 | 0.29 | 0.23 |
| 1970 Mean | 0.39 | 0.51 | 0.62 | 0.82 | 0.80 | 0.60 | .62 | .64 | .79 | 1.16 | .87 |
| Spring 1971 | 0.68 | 0.90 | 1.21 | 1.62 | 1.67 | 1.10 | 1.20 | 1.98 | 1.70 | 1.90 | 1.86 |
| Summer 1971 | 0.31 | 0.30 | 0.26 | 0.23 | 0.28 | 0.24 | 0.27 | 0.27 | 0.23 | 0.26 | 0.25 |
| Fall 1971 | 0.19 | 0.18 | 0.14 | 0.19 | 0.13 | 0.13 | 0.16 | 0.20 | 0.20 | 0.28 | 0.23 |
| 1971 Mean | 0.39 | 0.46 | 0.54 | 0.68 | 0.69 | 0.49 | 0.54 | 0.82 | 0.71 | 0.81 | 0.78 |
| Spring 1972 | 1.12 | 1.04 | 1.08 | 0.96 | 1.02 | 1.26 | 1.08 | 5.78 | 4.73 | 4.75 | 5.09 |
| Summer 1972 | 0.16 | 0.17 | 0.27 | 0.37 | 0.44 | 0.30 | 0.28 | 0.42 | 0.39 | 1.06 | 0.62 |
| Fall 1972 | 0.76 | 0.58 | 0.75 | 1.11 | 0.64 | 1.49 | 0.89 | 5.33 | 5.31 | 6.22 | 5.62 |
| 1972 Mean | 0.68 | 0.60 | 0.70 | 0.81 | 0.70 | 1.02 | 0.75 | 3.84 | 3.48 | 4.01 | 3.78 |

Table A10 (con't.)

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1973 | 0.56 | 0.59 | 0.70 | 0.68 | 0.53 | 0.98 | 0.67 | 2.20 | 2.20 | 2.68 | 2.36 |
| Summer 1973 | 0.41 | 0.45 | 0.40 | 0.53 | 0.47 | 0.55 | 0.47 | 0.62 | 0.66 | 0.97 | 0.75 |
| Fall 1973 | 0.16 | 0.17 | 0.21 | 0.19 | 0.16 | 0.16 | 0.18 | 0.35 | 0.34 | 0.62 | 0.44 |
| 1973 Mean | 0.40 | 0.40 | 0.44 | 0.47 | 0.39 | 0.56 | 0.44 | 1.06 | 1.07 | 1.42 | 1.18 |
| Spring 1974 | 0.66 | 0.67 | 0.83 | 1.00 | 0.89 | 1.40 | 0.91 | 2.89 | 2.70 | 3.02 | 2.87 |
| Summer 1974 | 0.16 | 0.11 | 0.12 | 0.11 | 0.14 | 0.17 | 0.14 | 0.17 | 0.18 | 0.27 | 0.21 |
| Fall 1974 | 0.15 | 0.12 | 0.15 | 0.14 | 0.14 | 0.15 | 0.14 | 0.21 | 0.26 | 0.46 | 0.31 |
| 1974 Mean | 0.32 | 0.30 | 0.37 | 0.42 | 0.39 | 0.57 | 0.40 | 1.09 | 1.05 | 1.26 | 1.13 |
| Spring 1975 |  |  | 1.23 |  |  | 1.80 | 1.52 |  | 2.48 | 3.24 | 2.86 |
| Spring Mean | 0.76 | 0.87 | 1.06 | 1.25 | 1.21 | 1.21 | 1.06 | 2.88 | 2.65 | 3.01 | 2.85 |
| Summer Mean | 0.24 | 0.24 | 0.25 | 0.30 | 0.32 | 0.30 | 0.28 | 0.33 | 0.35 | 0.61 | 0.43 |
| Fall Mean | 0.29 | 0.25 | 0.29 | 0.37 | 0.26 | 0.43 | 0.32 | 1.26 | 1.26 | 1.57 | 1.37 |

Table A11. Seasonal and annual means of total Kjeldahl nitrogen concentrations in mg/l by stations.

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1970 | 0.57 | 0.54 | 0.71 | 0.65 | 0.70 | 0.49 | 0.61 | 1.47 | 1.11 | 1.35 | 1.31 |
| Summer 1970 | 0.56 | 0.52 | 0.51 | 0.53 | 0.60 | 0.56 | 0.55 | 1.66 | 1.64 | 1.25 | 1.52 |
| Fall 1970 | 0.64 | 0.62 | 0.57 | 0.58 | 0.62 | 0.63 | 0.61 | 1.10 | 1.43 | 1.20 | 1.24 |
| 1970 Mean | 0.59 | 0.56 | 0.60 | 0.59 | 0.64 | 0.56 | 0.59 | 1.41 | 1.39 | 1.27 | 1.36 |
| Spring 1971 | 0.50 | 0.46 | 0.54 | 0.48 | 0.43 | 0.40 | 0.47 | 1.44 | 1.35 | 1.39 | 1.40 |
| Summer 1971 | 0.75 | 0.76 | 0.70 | 0.74 | 0.66 | 0.60 | 0.70 | 1.14 | 0.96 | 1.17 | 1.09 |
| Fall 1971 | 0.77 | 0.86 | 0.69 | 0.79 | 0.73 | 0.78 | 0.77 | 1.38 | 1.14 | 1.81 | 1.45 |
| 1971 Mean | 0.67 | 0.69 | 0.64 | 0.67 | 0.61 | 0.59 | 0.65 | 1.32 | 1.15 | 1.44 | 1.31 |
| Spring 1972 | 0.60 | 0.55 | 0.54 | 0.63 | 0.61 | 0.38 | 0.55 | 1.15 | 1.12 | 2.02 | 1.43 |
| Summer 1972 | 0.87 | 0.81 | 0.70 | 0.76 | 0.86 | 0.66 | 0.77 | 1.16 | 1.21 | 2.11 | 1.49 |
| Fall 1972 | 1.08 | 0.87 | 1.05 | 1.04 | 0.96 | 0.99 | 1.00 | 1.70 | 1.67 | 2.12 | 1.83 |
| 1972 Mean | 0.85 | 0.74 | 0.76 | 0.81 | 0.81 | 0.68 | 0.77 | 1.34 | 1.33 | 2.08 | 1.58 |

Table A11 (con't.)

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1973 | 0.87 | 0.86 | 1.01 | 0.79 | 0.66 | 0.76 | 0.82 | 1.48 | 1.39 | 1.63 | 1.50 |
| Summer 1973 | 0.88 | 0.80 | 0.74 | 0.82 | 0.81 | 0.78 | 0.81 | 1.23 | 1.16 | 1.98 | 1.46 |
| Fall 1973 | 0.74 | 0.70 | 0.63 | 0.67 | 0.64 | 0.70 | 0.69 | 1.05 | 1.05 | 2.08 | 1.39 |
| 1973 Mean | 0.83 | 0.79 | 0.79 | 0.76 | 0.71 | 0.75 | 0.77 | 1.25 | 1.20 | 1.90 | 1.45 |
| Spring 1974 | 0.77 | 0.77 | 0.59 | 0.58 | 0.54 | 0.59 | 0.63 | 1.03 | 1.02 | 1.20 | 1.08 |
| Summer 1974 | 0.76 | 0.79 | 0.76 | 0.77 | 0.76 | 0.81 | 0.77 | 0.99 | 1.02 | 2.37 | 1.46 |
| Fall 1974 | 0.65 | 0.61 | 0.60 | 0.55 | 0.56 | 0.48 | 0.58 | 1.08 | 0.93 | 2.74 | 1.59 |
| 1974 Mean | 0.73 | 0.70 | 0.65 | 0.63 | 0.62 | 0.63 | 0.64 | 1.03 | 0.99 | 2.11 | 1.37 |
| Spring 1975 |  |  | 0.70 |  |  | 0.78 | 0.74 |  | 0.94 | 1.41 | 1.18 |
| Spring Mean | 0.66 | 0.64 | 0.68 | 0.63 | 0.59 | 0.52 | 0.62 | 1.31 | 1.20 | 1.52 | 1.34 |
| Summer Mean | 0.76 | 0.74 | 0.68 | 0.72 | 0.74 | 0.68 | 0.72 | 1.24 | 1.20 | 1.78 | 1.40 |
| Fall Mean | 0.78 | 0.73 | 0.71 | 0.73 | 0.70 | 0.72 | 0.73 | 1.26 | 1.24 | 1.99 | 1.50 |

Table A12. Seasonal and annual means of ammonia nitrogen concentrations in mg/l by stations.

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1970 | 0.33 | 0.27 | 0.23 | 0.25 | 0.27 | 0.24 | 0.26 | 0.40 | 0.32 | 0.36 | 0.36 |
| *Summer 1970 | 0.22 | 0.30 | 0.18 | 0.16 | 0.20 | 0.23 | 0.22 | 0.14 | 0.18 | 0.29 | 0.20 |
| **Fall 1970 | 0.73 | 0.64 | 0.63 | 0.57 | 0.63 | 0.67 | 0.65 | 0.76 | 0.79 | 1.15 | 0.90 |
| 1970 Mean | 0.43 | 0.40 | 0.35 | 0.33 | 0.37 | 0.38 | 0.38 | 0.43 | 0.43 | 0.60 | 0.49 |
| Spring 1971 | 0.22 | 0.16 | 0.20 | 0.19 | 0.18 | 0.20 | 0.19 | 0.42 | 0.52 | 0.48 | 0.47 |
| Summer 1971 | 0.17 | 0.15 | 0.17 | 0.18 | 0.13 | 0.12 | 0.15 | 0.46 | 0.37 | 0.47 | 0.44 |
| Fall 1971 | 0.29 | 0.27 | 0.25 | 0.31 | 0.24 | 0.24 | 0.27 | 0.50 | 0.55 | 0.71 | 0.58 |
| 1971 Mean | 0.23 | 0.19 | 0.21 | 0.23 | 0.18 | 0.19 | 0.20 | 0.46 | 0.48 | 0.55 | 0.50 |
| Spring 1972 | 0.21 | 0.21 | 0.19 | 0.19 | 0.19 | 0.10 | 0.18 | 0.51 | 0.53 | 1.03 | 0.67 |
| Summer 1972 | 0.18 | 0.14 | 0.10 | 0.14 | 0.12 | 0.11 | 0.13 | 0.33 | 0.37 | 0.81 | 0.50 |
| Fall 1972 | 0.08 | 0.10 | 0.05 | 0.07 | 0.08 | 0.07 | 0.07 | 0.36 | 0.20 | 0.46 | 0.34 |
| 1972 Mean | 0.16 | 0.15 | 0.11 | 0.13 | 0.13 | 0.09 | 0.13 | 0.40 | 0.37 | 0.77 | 0.50 |

* Based on one sampling date.
** Based on three sampling dates.

Table A12 (con't.)

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1973 | 0.06 | 0.03 | 0.04 | 0.01 | 0.03 | 0.02 | 0.03 | 0.25 | 0.24 | 0.31 | 0.27 |
| Summer 1973 | 0.06 | 0.05 | 0.04 | 0.06 | 0.03 | 0.03 | 0.05 | 0.19 | 0.24 | 0.43 | 0.29 |
| Fall 1973 | 0.03 | 0.04 | 0.04 | 0.01 | 0.02 | 0.01 | 0.03 | 0.14 | 0.15 | 0.46 | 0.25 |
| 1973 Mean | 0.05 | 0.04 | 0.04 | 0.03 | 0.03 | 0.02 | 0.03 | 0.19 | 0.21 | 0.40 | 0.27 |
| Spring 1974 | 0.08 | 0.08 | 0.13 | 0.11 | 0.05 | 0.05 | 0.08 | 0.19 | 0.17 | 0.09 | 0.15 |
| Summer 1974 | 0.09 | 0.04 | 0.05 | 0.06 | 0.04 | 0.09 | 0.06 | 0.17 | 0.17 | 0.70 | 0.35 |
| Fall 1974 | 0.10 | 0.10 | 0.10 | 0.10 | 0.07 | 0.06 | 0.09 | 0.27 | 0.22 | 1.21 | 0.57 |
| 1974 Mean | 0.09 | 0.07 | 0.09 | 0.09 | 0.05 | 0.07 | 0.08 | 0.21 | 0.19 | 0.67 | 0.35 |
| Spring 1975 |  |  | 0.18 |  |  | 0.16 | 0.17 |  | 0.23 | 0.30 | 0.27 |
| Spring Mean | 0.18 | 0.15 | 0.16 | 0.15 | 0.14 | 0.12 | 0.15 | 0.35 | 0.36 | 0.45 | 0.38 |
| Summer Mean | 0.14 | 0.14 | 0.11 | 0.12 | 0.10 | 0.12 | 0.12 | 0.26 | 0.27 | 0.54 | 0.36 |
| Fall Mean | 0.25 | 0.23 | 0.21 | 0.21 | 0.21 | 0.21 | 0.22 | 0.41 | 0.38 | 0.80 | 0.53 |

Table A13. Seasonal and annual means of organic nitrogen concentrations in mg/l by stations.

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1970 | 0.36 | 0.29 | 0.46 | 0.39 | 0.43 | 0.25 | 0.36 | 1.07 | 0.80 | 0.94 | 0.94 |
| *Summer 1970 | 0.39 | 0.21 | 0.26 | 0.40 | 0.32 | 0.25 | 0.31 | 1.61 | 1.20 | 1.14 | 1.28 |
| **Fall 1970 | 0.09 | 0.07 | 0.07 | 0.08 | 0.10 | 0.08 | 0.08 | 0.36 | 0.31 | 0.24 | 0.31 |
| 1970 Mean | 0.28 | 0.19 | 0.26 | 0.29 | 0.28 | 0.19 | 0.25 | 1.01 | 0.77 | 0.77 | 0.84 |
| Spring 1971 | 0.31 | 0.30 | 0.34 | 0.29 | 0.26 | 0.19 | 0.28 | 1.15 | 0.89 | 1.14 | 1.06 |
| Summer 1971 | 0.58 | 0.61 | 0.54 | 0.56 | 0.52 | 0.48 | 0.55 | 0.67 | 0.58 | 0.69 | 0.65 |
| Fall 1971 | 0.48 | 0.59 | 0.45 | 0.47 | 0.48 | 0.54 | 0.50 | 0.89 | 0.59 | 1.10 | 0.86 |
| 1971 Mean | 0.46 | 0.50 | 0.44 | 0.44 | 0.42 | 0.40 | 0.44 | 0.90 | 0.69 | 0.98 | 0.86 |
| Spring 1972 | 0.39 | 0.37 | 0.35 | 0.45 | 0.42 | 0.28 | 0.38 | 0.64 | 0.60 | 0.98 | 0.74 |
| Summer 1972 | 0.70 | 0.66 | 0.59 | 0.62 | 0.74 | 0.55 | 0.73 | 0.80 | 0.84 | 1.30 | 0.98 |
| Fall 1972 | 1.00 | 0.74 | 1.01 | 0.97 | 0.88 | 0.92 | 0.92 | 1.34 | 1.47 | 1.66 | 1.49 |
| 1972 Mean | 0.70 | 0.59 | 0.65 | 0.68 | 0.68 | 0.58 | 0.68 | 0.93 | 0.97 | 1.31 | 1.07 |

*Based on one sampling date.
**Based on three sampling dates.

Table A13 (con't.)

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1973 | 0.81 | 0.83 | 0.97 | 0.78 | 0.63 | 0.74 | 0.79 | 1.23 | 1.15 | 1.32 | 1.23 |
| Summer 1973 | 0.82 | 0.75 | 0.70 | 0.76 | 0.78 | 0.75 | 0.76 | 1.04 | 0.92 | 1.55 | 1.17 |
| Fall 1973 | 0.71 | 0.66 | 0.59 | 0.66 | 0.62 | 0.69 | 0.66 | 0.91 | 0.90 | 1.62 | 1.14 |
| 1973 Mean | 0.78 | 0.75 | 0.75 | 0.73 | 0.68 | 0.73 | 0.74 | 1.06 | 0.99 | 1.50 | 1.18 |
| Spring 1974 | 0.69 | 0.62 | 0.46 | 0.47 | 0.49 | 0.54 | 0.55 | 0.84 | 0.85 | 1.11 | 0.93 |
| Summer 1974 | 0.67 | 0.75 | 0.71 | 0.71 | 0.72 | 0.72 | 0.71 | 0.82 | 0.85 | 1.67 | 1.11 |
| Fall 1974 | 0.55 | 0.51 | 0.50 | 0.45 | 0.49 | 0.42 | 0.49 | 0.81 | 0.71 | 1.53 | 1.02 |
| 1974 Mean | 0.64 | 0.63 | 0.56 | 0.54 | 0.57 | 0.56 | 0.58 | 0.82 | 0.80 | 1.44 | 1.02 |
| Spring 1975 |  |  | 0.52 |  |  | 0.62 | 0.57 |  | 0.71 | 1.11 | 0.91 |
| Spring Mean | 0.51 | 0.48 | 0.52 | 0.48 | 0.45 | 0.40 | 0.47 | 0.99 | 0.86 | 1.10 | 0.98 |
| Summer Mean | 0.63 | 0.60 | 0.56 | 0.61 | 0.62 | 0.55 | 0.61 | 0.99 | 0.88 | 1.27 | 1.04 |
| Fall Mean | 0.57 | 0.51 | 0.52 | 0.53 | 0.51 | 0.53 | 0.53 | 0.86 | 0.80 | 1.23 | 0.96 |

Table A14. Seasonal and annual means of inorganic nitrogen concentrations in mg/l by stations.

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1970 | 1.10 | 1.43 | 1.68 | 2.20 | 2.20 | 1.56 | 1.70 | 1.94 | 2.22 | 3.05 | 2.41 |
| *Summer 1970 | 0.56 | 0.50 | 0.63 | 0.82 | 0.80 | 0.71 | 0.67 | 0.37 | 0.54 | 0.74 | 0.55 |
| **Fall 1970 | 0.93 | 0.95 | 0.87 | 0.77 | 0.87 | 0.94 | 0.89 | 1.00 | 1.09 | 1.45 | 1.18 |
| 1970 Mean | 0.86 | 0.96 | 1.06 | 1.27 | 1.29 | 1.07 | 1.09 | 1.10 | 1.28 | 1.75 | 1.38 |
| Spring 1971 | 0.89 | 1.07 | 1.42 | 1.81 | 1.85 | 1.40 | 1.41 | 2.41 | 2.22 | 2.37 | 2.33 |
| Summer 1971 | 0.47 | 0.45 | 0.43 | 0.40 | 0.41 | 0.36 | 0.42 | 0.69 | 0.60 | 0.73 | 0.67 |
| Fall 1971 | 0.47 | 0.45 | 0.39 | 0.50 | 0.38 | 0.38 | 0.43 | 0.70 | 0.74 | 0.99 | 0.81 |
| 1971 Mean | 0.61 | 0.66 | 0.74 | 0.90 | 0.88 | 0.71 | 0.75 | 1.27 | 1.19 | 1.36 | 1.27 |
| Spring 1972 | 1.33 | 1.25 | 1.28 | 1.15 | 1.21 | 1.36 | 1.26 | 6.29 | 5.03 | 5.77 | 5.70 |
| Summer 1972 | 0.39 | 0.35 | 0.41 | 0.59 | 0.60 | 0.48 | 0.47 | 1.18 | 1.09 | 2.63 | 1.63 |
| Fall 1972 | 0.69 | 0.56 | 0.62 | 0.95 | 0.76 | 1.27 | 0.81 | 4.66 | 4.63 | 5.24 | 4.86 |
| 1972 Mean | 0.80 | 0.72 | 0.77 | 0.90 | 0.86 | 1.04 | 0.85 | 4.04 | 3.58 | 4.55 | 4.07 |

*Based on one sampling date.
**Based on three sampling dates.

Table A14 (con't.)

| Station | 1 | 2 | 3 | 4 | 5 | 6 | Lake Mean | 7 | 8 | 9 | Inshore Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring 1973 | 0.62 | 0.62 | 0.74 | 0.69 | 0.56 | 1.00 | 0.70 | 2.45 | 2.44 | 2.99 | 2.63 |
| Summer 1973 | 0.47 | 0.50 | 0.44 | 0.59 | 0.50 | 0.58 | 0.52 | 0.81 | 0.90 | 1.40 | 1.04 |
| Fall 1973 | 0.91 | 0.21 | 0.25 | 0.20 | 0.18 | 0.17 | 0.21 | 0.49 | 0.49 | 1.08 | 0.69 |
| 1973 Mean | 0.43 | 0.44 | 0.48 | 0.50 | 0.42 | 0.58 | 0.47 | 1.25 | 1.28 | 1.82 | 1.45 |
| Spring 1974 | 0.74 | 0.75 | 0.96 | 1.11 | 0.94 | 1.45 | 0.99 | 2.08 | 2.87 | 3.11 | 3.02 |
| Summer 1974 | 0.25 | 0.15 | 0.17 | 0.17 | 0.18 | 0.26 | 0.20 | 0.34 | 0.35 | 0.97 | 0.56 |
| Fall 1974 | 0.25 | 0.22 | 0.25 | 0.24 | 0.21 | 0.21 | 0.23 | 0.48 | 0.48 | 1.67 | 0.88 |
| 1974 Mean | 0.41 | 0.37 | 0.46 | 0.51 | 0.44 | 0.64 | 0.48 | 1.30 | 1.24 | 1.93 | 1.48 |
| Spring 1975 |  |  | 1.41 |  |  | 1.96 | 1.69 |  | 2.71 | 3.54 | 3.13 |
| Spring Mean | 0.94 | 1.02 | 1.22 | 1.39 | 1.35 | 1.35 | 1.21 | 3.03 | 2.96 | 3.46 | 3.22 |
| Summer Mean | 0.43 | 0.39 | 0.42 | 0.51 | 0.50 | 0.48 | 0.46 | 0.68 | 0.70 | 1.29 | 0.89 |
| Fall Mean | 0.51 | 0.48 | 0.48 | 0.53 | 0.48 | 0.59 | 0.51 | 1.47 | 1.49 | 2.09 | 1.68 |

MICHIGAN STATE UNIVERSITY

OFFICE FOR RESEARCH DEVELOPMENT
INSTITUTE OF WATER RESEARCH · DIRECTOR
NATURAL RESOURCES BUILDING

EAST LANSING · MICHIGAN · 48824

PB263557

February 10, 1977

National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

ATTN: Input Section

We are forwarding under separate cover twenty-one (21) copies of a document for deposit: CHLORIDE AND NITROGEN CONCENTRATIONS ALONG THE WEST SHORE OF LAKE ERIE, by Thomas J. ECker and Richard A. Cole, Report No. MSU-IWR-TR-76-0032.8.

The $40.00 deposit fee is to be deducted from Deposit Account 84551-1. This will leave us with a balance of $170.00.

Sincerely yours,

Mayanne Richardson

Mrs. Mayanne Richardson
Administrative Assistant

a